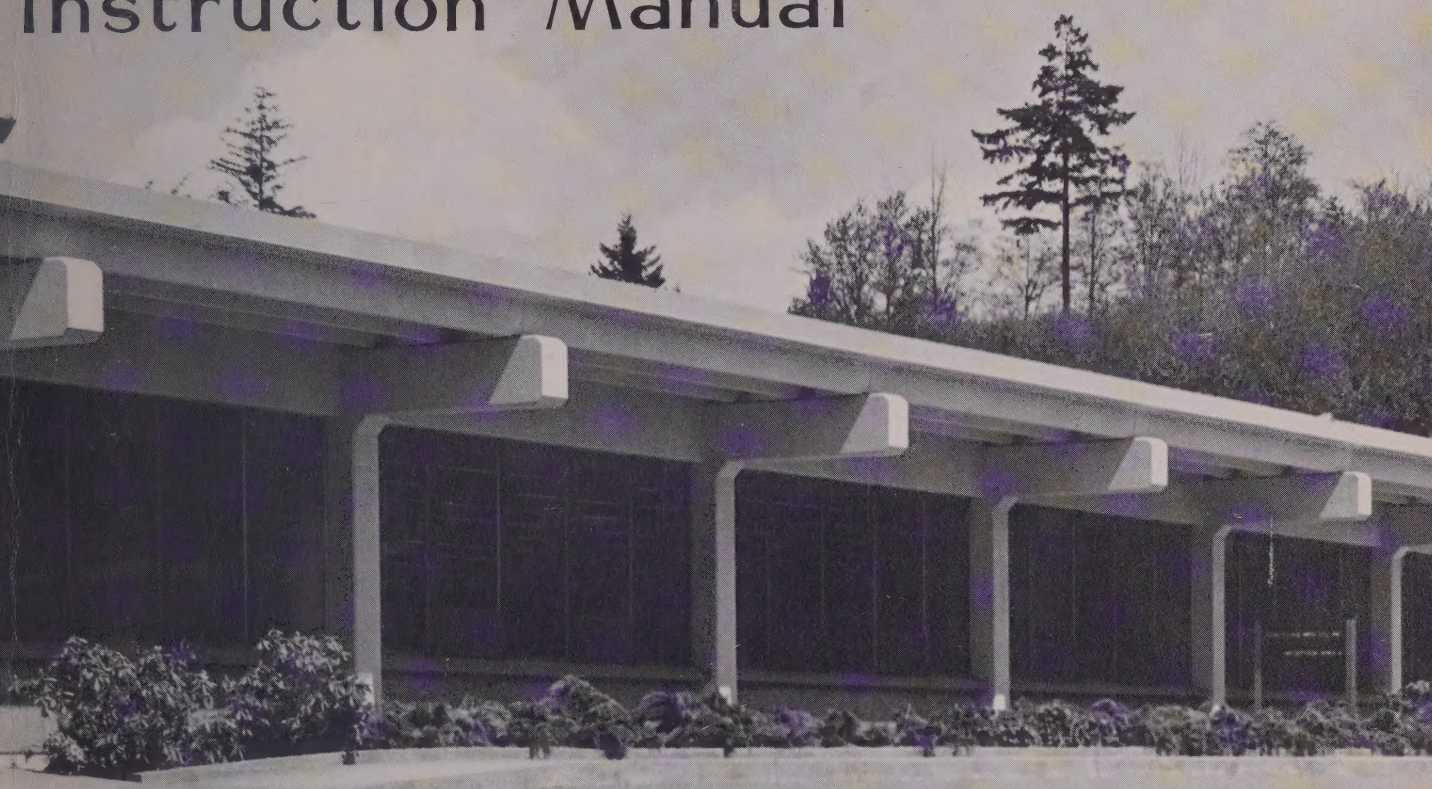
896 A.T.S.P.G.

Instruction Manual



MODEL

1900A

MULTI–COUNTER

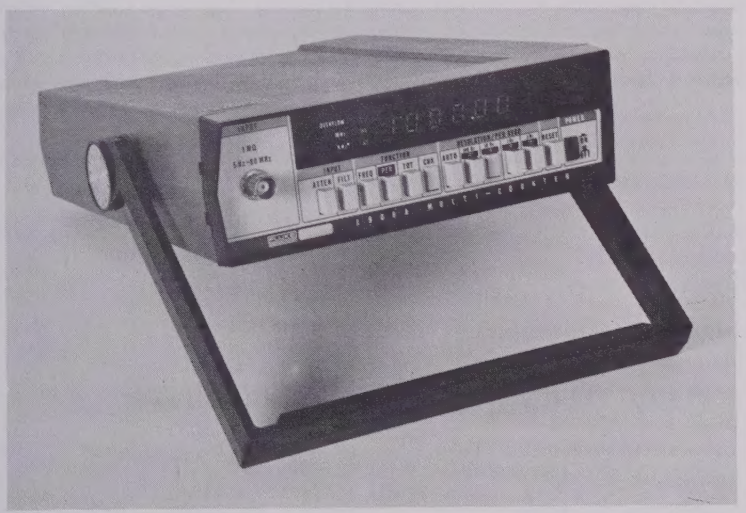
FLUKE®

JOHN FLUKE mfg. co., inc.
SEATTLE, WASHINGTON

JOHN FLUKE MFG. CO., INC.

P. O. Box 7428

Seattle, Washington 98133



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2. On receipt of the shipping instructions, forward the instrument prepaid, and repairs will be made at the factory. If requested, an estimate will be made before the work begins, provided the instrument is not covered by the Warranty.

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The John Fluke Mfg. Co., Inc.* will be happy to answer all application questions which will enhance your use of this instrument. Please address your requests to: JOHN FLUKE MFG. CO., INC., P. O. Box 7428, SEATTLE, WASHINGTON 98133*.

* For European customers: FLUKE (Nederland) B.V.
Ledeboerstraat 27
Tilburg, Netherlands

**For European customers, Air Freight prepaid.

FLUKE TECHNICAL SERVICE CENTERS

John Fluke Mfg. Co., Inc.
Bill Fetrow, Supervisor
7001 - 220th S.W.
Mountlake Terrace, WA 98043
Tel: 206-774-2206
TWX: 910-449-2850

Fluke Western Technical Center
Howard McElroy, Service Mgr.
2359 De La Cruz Blvd.
Santa Clara, CA 95050
Tel: 408-244-1505
TWX: 910-338-0121

Fluke Eastern Technical Center
Bernard Ciongoli, Service Mgr.
101 Berkshire Ave.
Paterson, NJ 07502
Tel: 201-742-3215

Fluke S.E. Technical Center
Jesse Morse, Service Mgr.
P.O. Box 6578
940 North Fern Creek Ave.
Orlando, FL 32803
Tel: 305-896-2296
TWX: 810-850-0185

Fluke Western Technical Center
Mike Nagy, Service Mgr.
1109 South Central Avenue
Glendale, CA 91204
Tel: 213-245-6716
TWX: 910-497-2086

Fluke Midwestern Technical Center
Bruce Hunt, Service Mgr.
1287 North Rand Road
Des Plaines, IL 60016
Tel: 312-298-7470
TWX: 910-233-4978

Fluke N.E. Technical Center
Dick Zemba, Service Mgr.
109 Massachusetts Avenue
Lexington, MA 02173
Tel: 617-861-8620
TWX: 710-326-1715

Fluke S.E. Technical Center
Dwain Cox, Service Mgr.
P.O. Box 9619
1310 Beaman Place
Greensboro, NC 27408
Tel: 919-273-1918
TWX: 510-925-1173

Fluke Western Technical Center
John Brunton, Service Mgr.
4805 Mercury St.
San Diego, CA 92111
Tel: 714-565-4455
TWX: 910-337-1273

Fluke Canadian Technical Center
Herb Duval, Service Mgr.
6427 Northam Drive
Mississauga, Ontario
Tel: 416-678-1500
TWX: 610-492-2119

Fluke Mideastern Technical Center
John Hines, Service Mgr.
11501 Huff Court
Kensington, MD 20795
Tel: 301-881-5300
TWX: 710-825-9645

Fluke (Nederland)
Karlis Bets, Service Mgr.
P.O. Box 5053
Ledeboerstraat 27
Tilburg - Netherlands
Tel: (013) 673973*
Telex 52237, Cable "Fluke"
H.R. Tilburg, 14629

FLUKE AUTHORIZED SERVICE LABS

Ball Brothers
Boulder Industrial Park
P.O. Box 1062
Boulder, CO 80302
Tel: 303-441-4710
TWX: 910-940-3241

Service Engineers
Larry Flood, Service Mgr.
28 Finney Street
Rochester, NY 14605
Tel: 716-232-2800

Missouri Research Lab
630 Haines, NW
Albuquerque, NM 87102
Tel: 505-243-6772
TWX: 910-989-1656

Linear Standards Lab
8207 Millet
Houston, TX 77012
Tel: 713-923-2796
TWX: NONE

Tucker Electronics
Clay Aclin, Service Mgr.
1717 Jupiter
Garland, TX 75040
Tel: 214-348-8800
TLX: 73-0401

Rev. 3/74

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Section 1

Introduction & Specifications

1-1. INTRODUCTION

1-2. The Fluke Model 1900A is a 5 Hz to 80 MHz multiple-function counter capable of making frequency, period, period averaging and totalize measurements. In the frequency mode, resolution is manually selectable at 0.1 Hz, 1.0 Hz, 10 Hz and 100 Hz. In the period averaging mode, the number of periods averaged is manually-selectable at 10^0, 10^1, 10^2 and 10^3 periods. Automatic selection of resolution and number of periods averaged is also provided to automatically select the optimum range for a particular input signal.

1-3. The measurement display is six digits, light-emitting-diode-type (LED) with leading-zero suppression and automatic decimal point positioning. Annunciators are provided to indicate measurement units (kHz, MHz, milliseconds and microseconds) and also overflow when the capacity of the display is exceeded. All displayed information is also available at a rear-panel connector when the unit is equipped with an optional Data Output Unit (DOU).

1-4. The Model 1900A is equipped with a selectable 1 MHz low-pass filter for use in electrically noisy environments, and a selectable 10:1 attenuator for use with high-level inputs. A self-check mode of operation is provided to verify overall performance of the unit. Power requirements are 100, 115 or 230 volts at 50 to 400 Hz for the line-powered version. An optional battery-powered version, Model 1900A–01, provides for use away from ac power lines and is equipped with rechargeable nickel-cadmium batteries. The battery-powered version also operates from the ac lines, but only at the power line frequency and voltage specified on the bottom of the instrument.

1-5. SPECIFICATIONS

1-6. The pertinent specifications for the Model 1900A are listed in the following Table 1-1.

Table 1-1. MODEL 1900A SPECIFICATIONS

FUNCTIONS

FREQUENCY MEASUREMENTS

Range	5 Hz to 80 MHz
Gate Time	10ms to 10s in decade steps
Accuracy	±1 count + timebase accuracy
Readout	kHz or MHz, decimal point automatically displayed

PERIOD MEASUREMENTS

Range	5 Hz to 1 MHz
Periods Averaged	10^0 to 10^3 periods in decade steps
Frequency Counted	10 MHz
Accuracy	±1 count + timebase accuracy + trigger error of signal. *
Readout	MS or US, decimal point automatically displayed

* *Trigger error is ±0.3% divided by the number of periods averaged, for input signals having better than 40 db S/N ratio and greater than 100 mV amplitude.*

TOTALIZING

Range	5 Hz to 80 MHz
Capacity	Totalizes to count of 999999 then activates overflow indicator.

TIMEBASE

CRYSTAL FREQUENCY	10 MHz

STABILITY

Aging Rate	< ±5 parts in 10^7/month
Temperature	< ±5 parts in 10^6, 0°C to 50°C
Line Voltage Regulation	< ±1 part in 10^7 for 10% line variation

Section 2
Operating Instructions

2-1. INTRODUCTION

2-2. This section contains operating information for the Model 1900A. The contents of this section should be read before operating the counter. Should any difficulties arise during operation of this instrument, please contact your nearest John Fluke Sales Representative, or the John Fluke Mfg. Co. Ltd., 2247 Midland Avenue, Scarborough, Ontario, M1P 4R1. A list of Sales Representatives is located at the rear of this manual.

2-3. SHIPPING INFORMATION

2-4. The Model 1900A is packaged and shipped in a foam-packed container. Upon receipt of the equipment, a thorough inspection should be made to reveal any possible shipping damage. Special instructions for inspection and claims are included in the shipping carton.

2-5. If reshipment of the equipment is necessary, the original container should be used. If the original container is not available, a new container can be obtained from the John Fluke Mfg. Co. Please reference the equipment model number when requesting a new shipping container.

2-6. INPUT POWER

2-7. The Models 1900A and 1900A–01 are supplied with one of three ac input power configurations. These consist of 100Vac, 115Vac and 230Vac; at 50 to 400 Hz. Before connecting to the ac line power, insure that the instrument is in the proper configuration for your power lines. A decal on the underside of the instrument indicates the ac line voltage and frequency required.

CAUTION

The battery-powered version must be operated at the line frequency stamped on the bottom-panel decal.

2-8. RACK INSTALLATION

2-9. The Model 1900A may be mounted in a standard 19-inch rack when supplied with the appropriate rack mounting kit. Rack mounting kits are available to allow left, right or center counting. Instructions for installing units in the rack mount are supplied with the rack mounting kit. These instructions are repeated in Section 6. The center rack mounting kit is Model No. M00-200-612. The offset rack mounting kit is Model No. M00-200-611.

2-10. OPERATING FEATURES

2-11. The location and function of all controls, connectors, and indicators are shown in Figure 2-1. Operating features and instructions for accessories are discussed in Section 6.

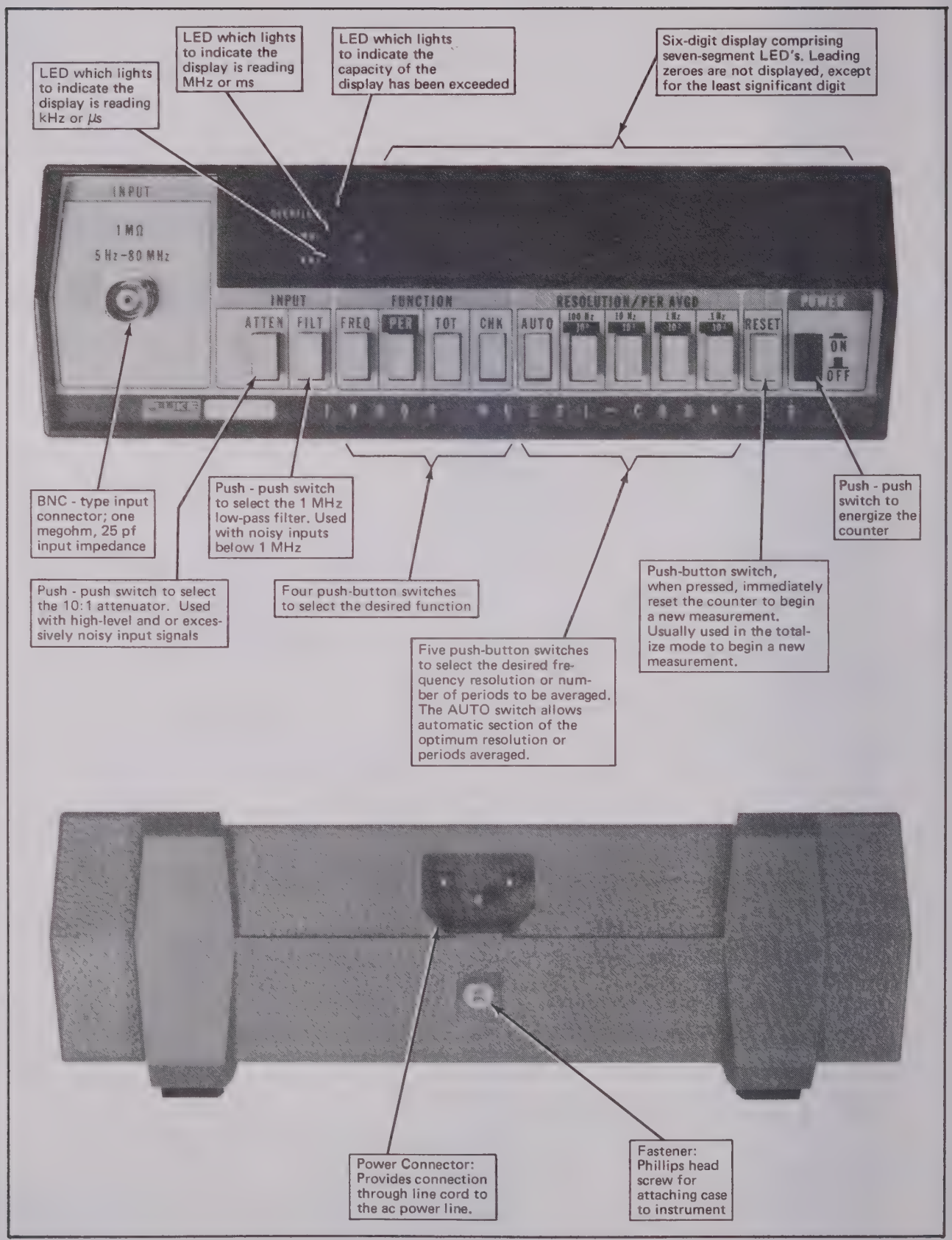

LED which lights to indicate the display is reading kHz or μs
LED which lights to indicate the display is reading MHz or ms
LED which lights to indicate the capacity of the display has been exceeded
Six-digit display comprising seven-segment LED's. Leading zeroes are not displayed, except for the least significant digit
INPUT
1 MΩ
5 Hz-80 MHz
INPUT
ATTEN
FILT
FUNCTION
FREQ
PER
TOT
CHK
RESOLUTION/PER AVGD
AUTO
RESET
POWER
ON
OFF
BNC - type input connector; one megohm, 25 pf input impedance
Push - push switch to select the 1 MHz low-pass filter. Used with noisy inputs below 1 MHz
Push - push switch to energize the counter
Push - push switch to select the 10:1 attenuator. Used with high-level and or excessively noisy input signals
Four push-button switches to select the desired function
Push-button switch, when pressed, immediately reset the counter to begin a new measurement. Usually used in the totalize mode to begin a new measurement.
Five push-button switches to select the desired frequency resolution or number of periods to be averaged. The AUTO switch allows automatic section of the optimum resolution or periods averaged.
Power Connector: Provides connection through line cord to the ac power line.
Fastener: Phillips head screw for attaching case to instrument

Figure 2-1. CONTROLS, CONNECTORS AND INDICATORS

2-12. OPERATING NOTES

2-13. Fuse

2-14. The line fuse, F1, is located inside the case near the power transformer. To gain access to this fuse, remove the retaining screw at the rear of the instrument case, and remove instrument from case.

2-15. Battery Power, Option –01

CAUTION

Damage may result if alkaline, zinc-carbon or mercury batteries are charged.

2-16. Power for the Model 1900A–01 is supplied by internal rechargeable batteries that allow the instrument to operate for at least four hours. Whenever the unit will not self-check properly, the batteries should be recharged. Recharging is most rapidly accomplished by switching to OFF and connecting the instrument to the ac power line. In this way, the discharged batteries can be completely charged in approximately 12 to 14 hours. The instrument can also be operated when recharging on ac power, but recharging time will be extended to approximately 56 hours.

NOTE

Battery manufacturers recommend that nickle-cadmium batteries should not be stored for extended periods of time without recharging at least every 90 days. Storage temperatures below 25°C are recommended.

2-17. Input Connection

2-18. Signals to be measured by the Model 1900A are applied to the front-panel BNC connector. Connection of all input signals should be by means of coaxial-type cable fitted with a mating BNC connector. Input impedance is one megohm shunted by 25 pf. Input sensitivity is 25 millivolts rms.

2-19. Overload Protection

2-20. The Model 1900A will accept inputs as high as 150 volts rms at frequencies below 1 kHz without damage. Overload capability decreases linearly from 150 volts rms at 1 kHz to 20 volts rms at 80 MHz input, as illustrated in Figure 2-2.

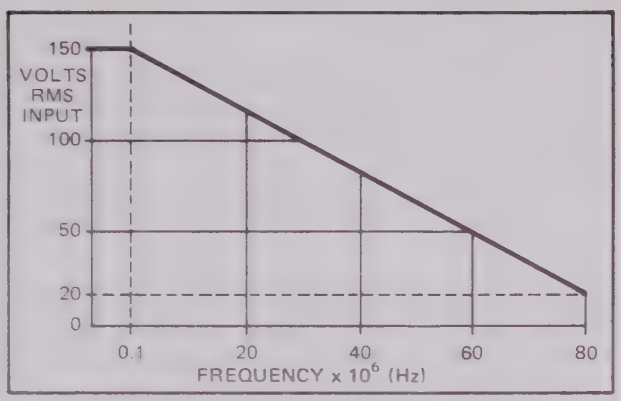


Figure 2-2. INPUT OVERLOAD PROTECTION LEVELS

2-21. FREQUENCY MEASUREMENTS

2-22. Perform frequency measurements as follows:

a. Press the POWER switch to the ON position.

b. Press the FREQ switch to select the frequency mode of operation.

c. Select the desired resolution, or the autorange mode by pressing the AUTO switch. If the input signal is completely unknown, the autorange mode will select the optimum range.

NOTE

In the autorange mode, automatic selection is made between the lower three resolutions. The 0.1 Hz resolution can only be manually selected (by means of the .1 Hz RESOLUTION switch).

d. Connect the input signal to the front-panel BNC connector. If the input signal is high level (refer to Figure 2-2 for acceptable input levels), press the ATTEN switch to reduce the input sensitivity by a factor of 10:1.

e. If the input signal is below 1 MHz, high-frequency noise can be eliminated by pressing the FILT switch.

f. Read the frequency on the display, and observe the unit of measurement indication (kHz or MHz) to the left of the display.

2-23. PERIOD MEASUREMENTS

2-24. Perform period measurements as follows:

a. Press the POWER switch to the ON position.

b. Press the PER switch to select the period mode of operation

c. Select the desired number of periods to be averaged, or the autorange mode by pressing the AUTO switch. If the input signal is completely unknown, the autorange mode will select the optimum number of periods to average.

NOTE

In the autorange mode, automatic selection is made between 10^0, 10^1 and 10^2 periods to be averaged. The 10^3 (1000) periods averaged can only be manually selected (by means of the 10^3 PER AVGD switch).

d. Connect the input signal to the front panel BNC connector. If the input signal is high level (refer to Figure 2-2 for acceptable input levels), press the ATTEN switch to reduce the input sensitivity by a factor of 10:1.

e. If the input signal is below 1 MHz, high-frequency noise can be eliminated by pressing the FILT switch.

f. Read the period time on the display, and observe the unit of measurement indication (ms or μs) to the left of the display.

2-25. TOTALIZE MEASUREMENTS

2-26. Perform totalize measurements as follows:

a. Press the POWER switch to the ON position.

b. Press the TOT switch to select the totalize mode of operation, and the RESET switch to initialize the counter.

c. Connect the input signal to the front-panel BNC connector. If the input signal is high level (refer to Figure 2-2 for acceptable input levels), press the ATTEN switch to reduce the input sensitivity by a factor of 10:1.

d. If the input signal is below 1 MHz, high-frequency noise can be eliminated by pressing the FILT switch.

e. Read the accumulated total on the display.

2-27. SELF-CHECK MODE

2-28. The self-check mode provides a means of verifying proper overall operation of counter, excluding input amplifier, attenuator and filter. To self-check the unit, proceed as follows:

a. Press the POWER switch to the ON position.

b. Press the CHK switch to select the self-check mode.

c. Press the 100 Hz RESOLUTION switch; the display should read 1.0000 MHz.

d. Press the 10 Hz RESOLUTION switch; the display should read 1000.00 kHz.

e. Press the 1 Hz RESOLUTION switch; the display should read 000.000 kHz, and light the OVFL annunciator.

f. Press the AUTO switch; the display should read 1000.00 kHz.

Section 3
Theory of Operation

3-1. INTRODUCTION

3-2. This section of the manual contains an overall functional description of the Model 1900A, followed by a more detailed block diagram analysis. Simplified block diagrams are included as necessary, to supplement the text.

3-3. OVERALL FUNCTIONAL DESCRIPTION

3-4. Frequency Mode

3-5. Generally, the frequency of any signal is measured by counting the number of cycles of the unknown signal for a known length of time, referred to as the gate time. Gate time is usually equal to seconds at some power of ten, i.e. one millisecond, ten milliseconds, etc. The longer the gate time, the greater the measurement resolution. The accumulated count of the input signal cycles is then fed to the display section where it is observed by the operator.

3-6. As shown in Figure 3-1, the Model 1900A comprises an input section, a main gate, decade counters/display memory/display multiplexer, display light emitting diodes, a time base oscillator, range control logic/time base dividers and program control logic. The unknown signal is applied to the input section where it is limited, amplified and shaped to a squarewave for application to one input of the main gate. The input section also contains a selectable 1 MHz low-pass filter and a selectable 10:1 attenuator.

3-7. In order for the input signal to be applied to the decade counters, a main gate enable signal is required at the second input of the main gate. The main gate enable signal is derived from the 1 MHz output of the time base oscillator/divider. The 1 MHz time base signal is applied to the range control logic and time base dividers, where it is divided by a factor of 10^4, 10^5, 10^6 or 10^7, depending upon which range (degree of resolution) is selected. If the 100 Hz resolution is selected, then the time base oscillator output is divided by a factor of 10^4 to yield a time base having a period of 10 milliseconds (0.01 seconds). For a time base of 100 milliseconds, a division factor of 10^5 is used, and so on.

3-8. The divided time base signal is applied to the main gate and enables the signal under measurement to pass through to the six series-connected decade counters for one full period of the divided time base. The decade counters continue to accumulate the gated pulses from the input signal as long as the main gate enable signal is present (i.e. for the period of the time base). At the end of the time base period, the main gate is inhibited and the counters no longer receive input pulses. At this time, the program control logic issues a memory update command to the display memory, causing the contents of the six decade counters to be stored in six memory units until the next memory update command occurs.

3-9. There are six decade counters, six four-bit memory units and six display light-emitting diodes (LED'S). However, the contents of only one memory unit (one digit of measurement data) is displayed on its corresponding LED at any given time. A display multiplexer sequentially places the contents of each memory unit on a measurement data bus for a period of approximately 90 microseconds.

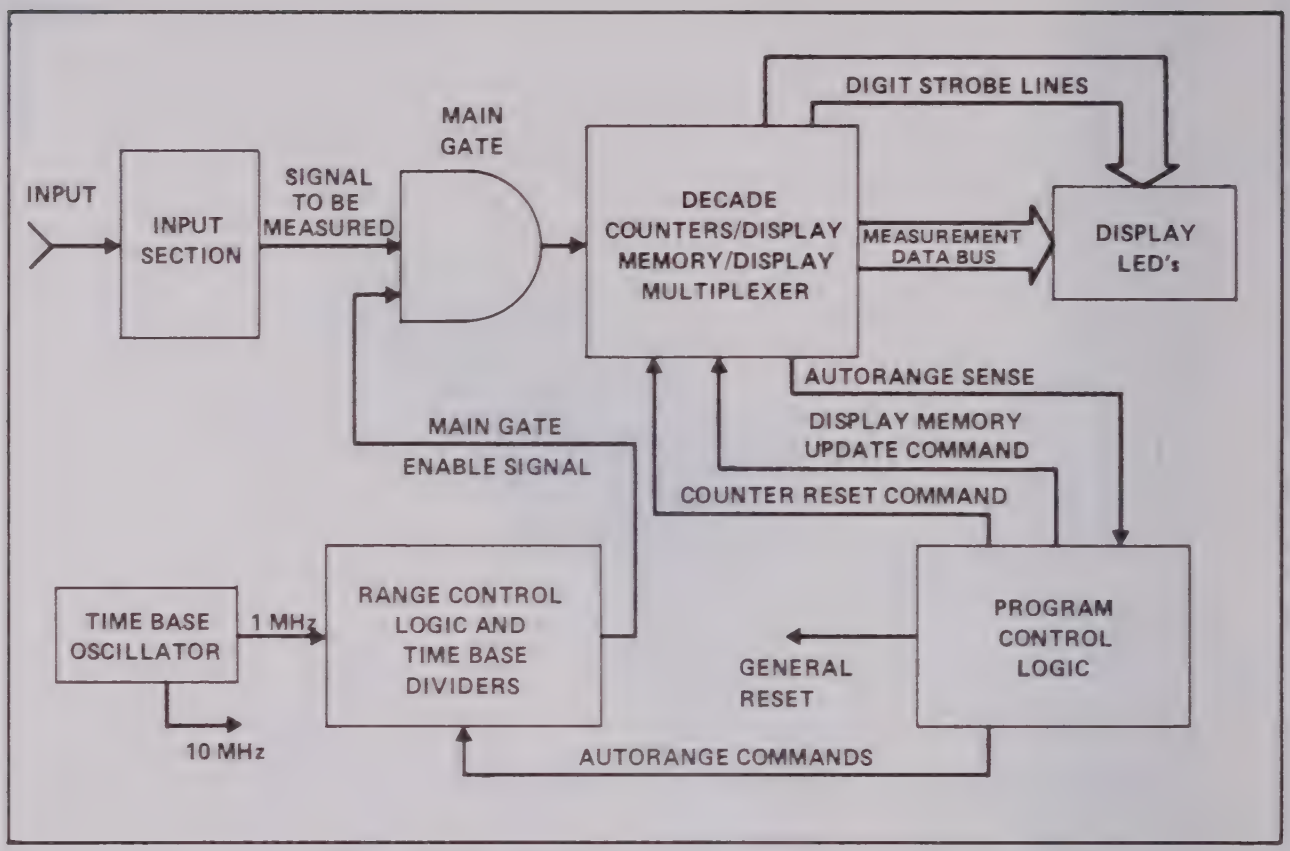


Figure 3-1. MODEL 1900A, SIMPLIFIED BLOCK DIAGRAM – FREQUENCY MODE

The measurement data bus is commonly connected to all digits (LED'S) in the display. However, only that digit which corresponds to the memory unit being gated is enabled by means of a strobe line. As the next memory unit is gated onto the measurement data bus, the next digit is strobed to display that data. As each memory unit is gated, the corresponding LED is strobed to display the data placed on the measurement data bus, resulting in a scanning action of the display. By sequencing through the display memory and lighting each LED for only 9% of the time, and power consumption is minimal. Persistence of the eye eliminates any effects of blinking or flicker.

3-10. While the last measurement is being displayed, the program control logic initiates the next measurement by generating a general reset command, to initialize various elements of the control logic. The general reset command is also used to reset the six decade counters back to zero in preparation for the next measurement.

3-11. Period Mode

3-12. The period of an unknown signal is measured by counting a known frequency during 1, 10, 100 or 1000 periods of the unknown input. Figure 3-2 shows how the Model 1900A uses the 10 MHz output of the timebase oscillator as the known frequency used to record time, while the unknown input is fed to the time base dividers to enable and inhibit the main gate.

3-13. In the period mode, the unknown input signal is used to enable the main gate at the beginning of a cycle. The decade counters accumulate the 10 MHz time base oscillator output during the time the main gate is enabled. At the beginning of a succeeding cycle of the input signal, the main gate is inhibited, and the decade counters cease to accumulate the 10 MHz time base signal. The contents of the counters indicate the elapsed time between successive cycles of the input signal. Depending upon the PER AVGD switch selection, the number of periods of the input signal used to enable and inhibit the main gate may be 1, 10, 100 or 1000. The more periods averaged, the better the resolution of the measurement.

3-14. The period information is transferred from the decade counters to the display memory by the program control logic. While stored in the memory, the period measurement is displayed in the same manner as previously described for the frequency mode of operation.

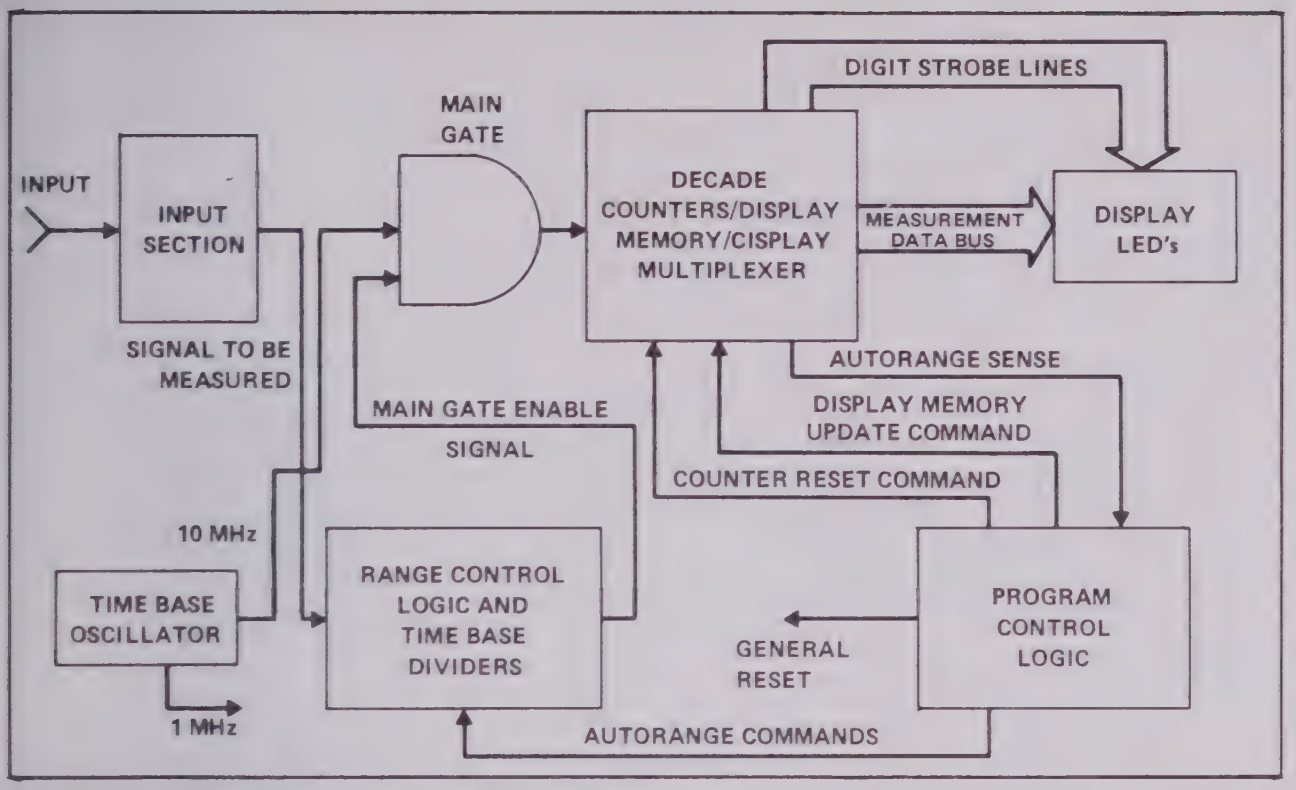


Figure 3-2. MODEL 1900A, SIMPLIFIED BLOCK DIAGRAM – PERIOD MODE

3-15. Totalize Mode

3-16. The configuration of the 1900A in the totalize mode is shown in Figure 3-3. In this mode, no time base signals, range control or control logic is used, since totalize is basically a manual operation. Operation is initiated by means of a manual reset command which resets all decade counters to zero. From this time, all input pulses, either random or uniform, are gated through to the decade counters due to the continuous main gate enable signal provided by the front-panel totalize switch.

3-17. As the decade counters accumulate the input pulses, their contents are continuously applied to the dis-

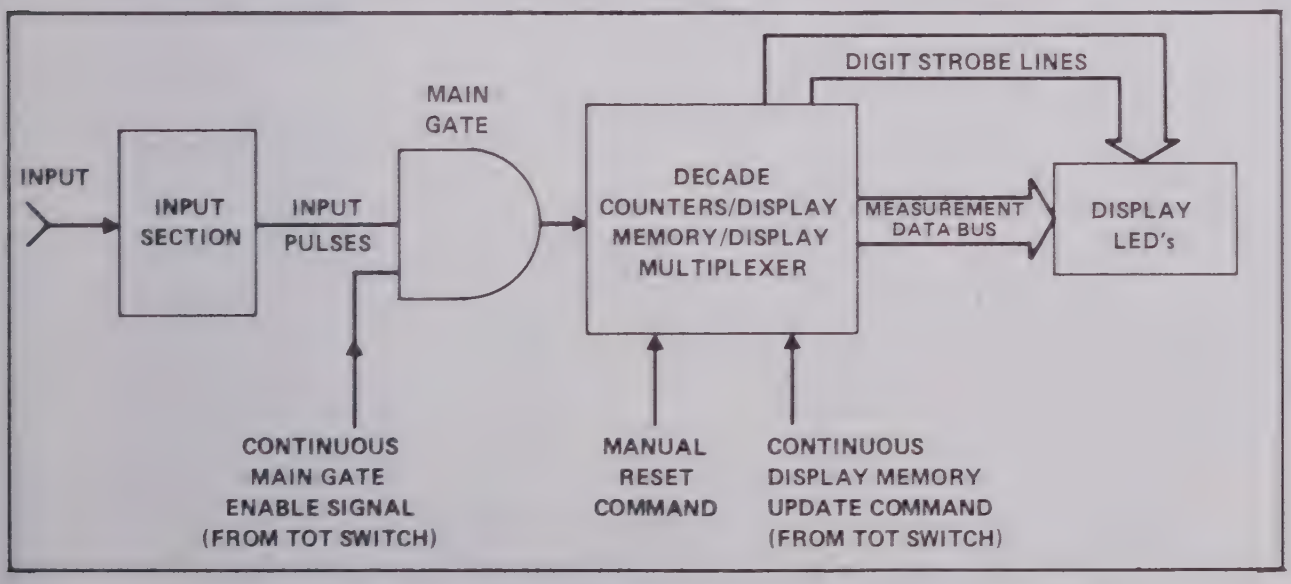


Figure 3-3. MODEL 1900A, SIMPLIFIED BLOCK DIAGRAM – TOTALIZE MODE

play memory due to the continuous display memory update command provided by the front panel totalize switch. As a result, the accumulated total is displayed at all times.

3-18. Self-Check Mode

3-19. Operation of the 1900A in the self-check mode is similar to that previously described for the frequency mode except that the unknown input is replaced by the 10 MHz output of time base oscillator. Refer to Figure 3-4.

3-20. Power Supply

3-21. LINE POWER

3-22. The line power supply provides regulated voltages of –12V dc and +5V dc and an unregulated +5V dc. The –12V dc is used as operating power for the input section, display multiplexer and logic control. The positive logic level voltage, used throughout the unit, is provided by the +5V dc power supply. The unregulated +5V dc is used to supply power for the digit drivers Q2 – Q7.

3-23. BATTERY POWER

3-24. When the battery power option is installed in the unit all operating voltages are derived from the +5V battery output voltage. The battery supplies the +5V positive logic voltage and digit driver voltage directly and produces the –12V dc power through a dc-to-dc power converter. The ac power line input is first rectified then applied to the battery as charging voltage.

3-25. BLOCK DIAGRAM ANALYSIS

3-26. Input Section

3-27. The function of the input section is to condition all input signals prior to application to the main gate. As shown in Figure 3-5, the signal to be measured, when applied to the input connector, is fed through buffer amplifier, Q1 and Q2. Resistors R6 and R7, connected to the collector of Q2, form a 10:1 attenuator controlled by Q3 and Q4. In the x1 position the ATTEN switch causes Q3 to conduct and pass the input signal unattenuated, while in the X10 position Q4 conducts and passes only one-tenth of the input signal.

3-28. After passing through the attenuator the signal can then be filtered if desired. The filter consists of C6, CR7 and CR8, C3 and R10. The FILT switch on the front panel applies +5V dc to R10, when the filter is selected (in), to forward bias the diodes CR7 and CR8. Input

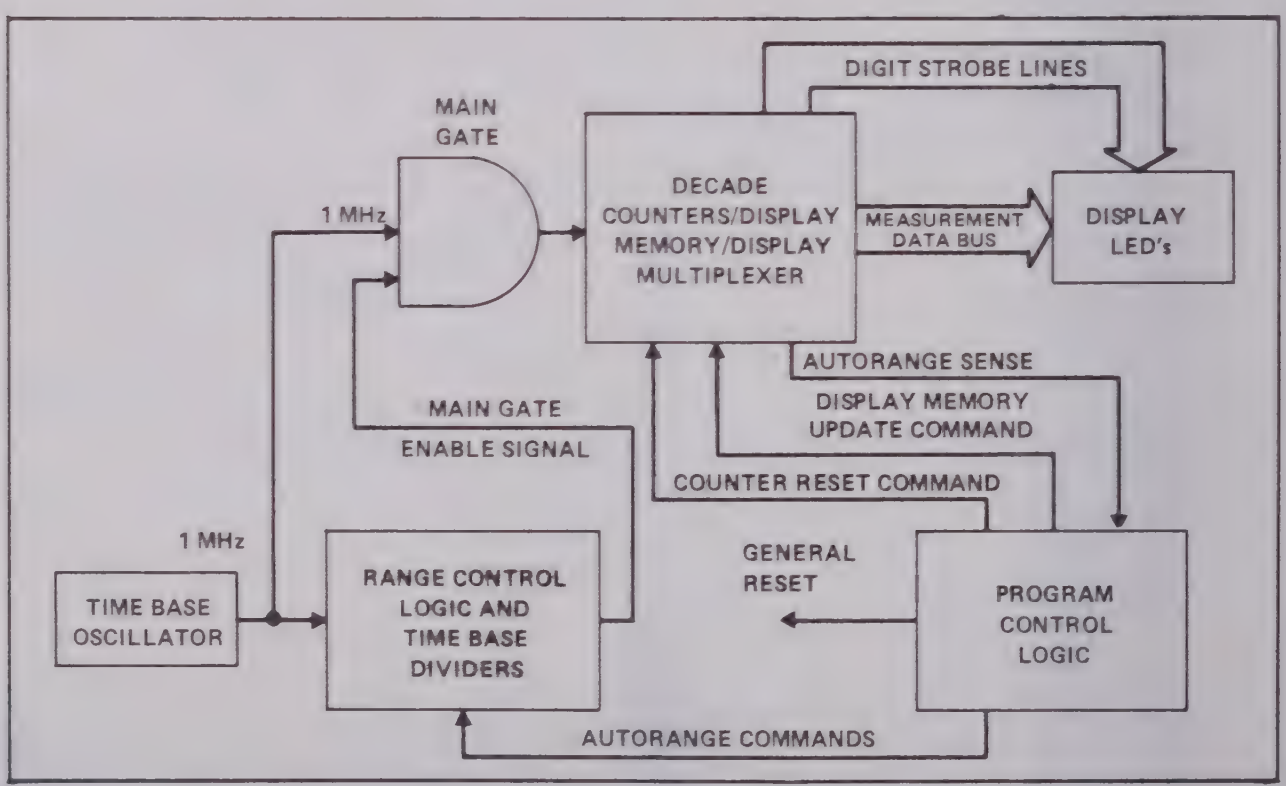


Figure 3-4. MODEL 1900A, SIMPLIFIED BLOCK DIAGRAM – SELF-CHECK MODE

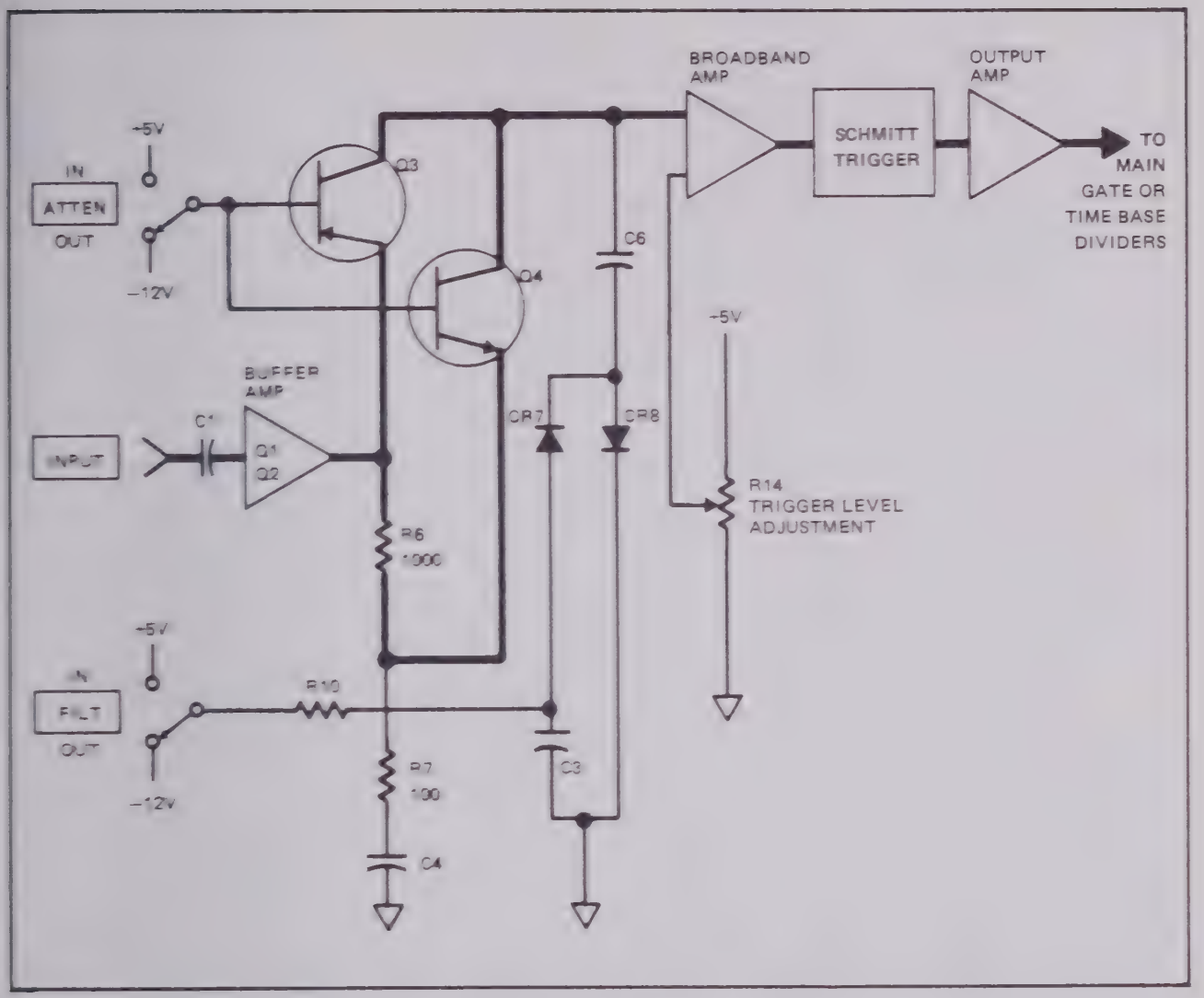


Figure 3-5. INPUT SECTION, BLOCK DIAGRAM

signals above 1 MHz are then shunted to ground through C6 and CR8. When the filter is out the −12V dc applied to R10 reverse biases the diodes allowing all input frequencies to pass.

3-29. Several stages follow the filter. A buffer amplifier precedes the trigger level adjustment in conjunction with R14. A succeeding broadband amplifier provides gain over the wide range of input frequencies and feeds the Schmitt trigger. The Schmitt trigger squares the input signal and feeds it to the output amplifier which translates the signal to standard TTL levels for application to the main gate (frequency and totalize modes) or time base dividers (period mode).

3-30. Main Gate/Decade Counters

3-31. The main gate is an integral part of the first of the six decade counters, as shown in Figure 3-6. The gating of input pulses to the decade counters from the input section (frequency and totalize modes) or time base dividers (period and self-check modes) is accomplished by applying an enable signal to the J and K inputs of the first stage of the first decade counter. Since the input pulses are applied to the clock input of the first stage, the J and K inputs must be true in order for the input pulses to toggle the first stage, which in turn, toggles the subsequent stages.

NOTE

Four of the six decade counters, the display memory, the display multiplexer and measurement data bus described in these paragraphs are contained in U24, and are not separately replaceable for the purpose of repair.

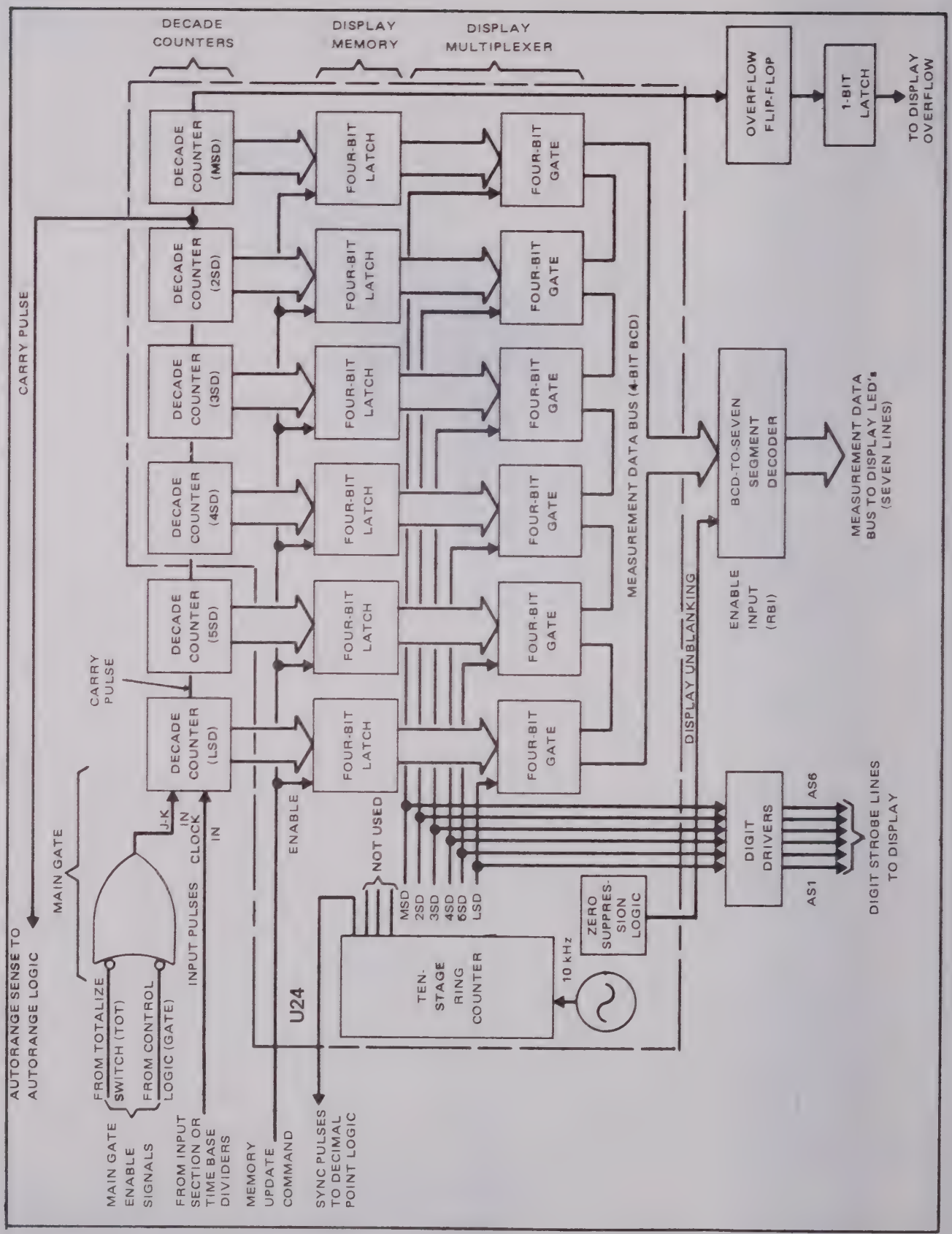


Figure 3-6. DECADE COUNTERS, DISPLAY MEMORY & DISPLAY MULTIPLEXER, BLOCK DIAGRAM

3-32. The main gate is enabled by the application of either of two commands; one generated by the TOT switch when in the totalize mode, and the other generated by the control logic in all other modes of operation. When enabled, the first decade counter (least significant digit) receives the input pulses, and issues a carry pulse to the succeeding decade counter (fifth significant digit). The carry output of each counter becomes the input to the succeeding counter. The carry output of the most significant digit decade counter is used to generate the overflow signal, which lights the OVFL indicator. The overflow signal becomes true whenever the MSD counter exceeds full count and wraps-around back to zero (i.e. on the trailing edge of the carry pulse).

3-33. Display Memory

3-34. The function of the display memory, shown in Figure 3-6, is to store the BCD contents of the decade counters after the measurement has been made, so that the multiplexer has access to settled data at all times. Without the display memory, the display would directly reflect the counting action of all the decade counters making it difficult to observe the final measurement. In the totalize mode, the display memory is not used and the contents of the counters at any given time, are displayed on the LED's.

3-35. The display memory comprises a set of six four-bit latches which accept their applied BCD inputs during the presence of a memory update command. The memory update command is generated by the control logic when it has determined that the contents of the decade counters are ready for display. (The control logic is described later in this section).

3-36. Display Multiplexer

3-37. The function of the display multiplexer is to sequentially gate each digit of measurement data from the outputs of the display memory onto a bus which is commonly connected to all display LED's. In conjunction, the display multiplexer also enables the corresponding LED at the same time its respective measurement data is placed on the bus. As shown in Figure 3-6, the Display multiplexer comprises a series of six four-bit gating circuits, a 10 kHz oscillator, a ten-stage ring counter and a measurement data bus (four-bit BCD). The 10 kHz oscillator drives the ten-stage ring counter through a complete cycle every millisecond. Each output is true for a period of 90 microseconds, providing a 10 microsecond guard period between each output.

3-38. Six of the ring counter outputs are used to enable the six four-bit gating circuits, and their corresponding display LED's. Three outputs are not used, and the tenth output is used to reset the zero suppression logic. As the ring counter progresses through its cycle, each of the gating circuits is sequentially enabled for a period of 90 microseconds to place its respective digit of measurement data on the measurement data bus for application to the display LED's. At the same time the digit of measurement data is placed on the bus, the ring counter output feeds the digit strobe line, via the corresponding LED drivers, to enable the corresponding display LED. Refer to Figure 3-7.

3-39. Prior to application to the display, the BCD measurement data is decoded to the seven-line format required by the display LED's. The digit strobe lines are fed through a series of drivers for application to the anodes (enable inputs) of the display LED's.

NOTE

The BCD-to-seven segment decoder is inhibited by zero suppression logic whenever non-significant leading zeroes are placed on the measurement data bus.

3-40. Decimal Point Logic

3-41. The position of the decimal point in the display is determined by the decimal point logic shown in Figure 3-8. The range information is applied to a pair of storage flip-flops, and is updated by the memory update command which is synchronized by a ring counter output of the display multiplexer by means of U11. The outputs of the flip-flops reflect the current operating range and are fed to a series of AND gates which, in conjunction with three of the digit strobe lines, decode the decimal point position to a particular LED in the display. In the totalize mode, the decimal point logic output is disconnected from the decimal point bus by means of the TOT switch.

3-42. Time Base Oscillator

3-43. The time base oscillator provides the main gate time base in the frequency and self-check modes, and provides the input signals to the decade counters in the period and self-check modes. The oscillator, shown in Figure 3-9, is a crystal controlled Colpitts which operates at 10 MHz. The 10 MHz signal is squared by Q15 and U17, and applied to a decade counter, U12, to obtain an output of 1 MHz. Both outputs are fed through the front-panel function switches to various sections of the counter.

3-44. Time Base Dividers

3-45. The function of the time base dividers, shown in Figure 3-10, is to divide the 1 MHz time base oscillator

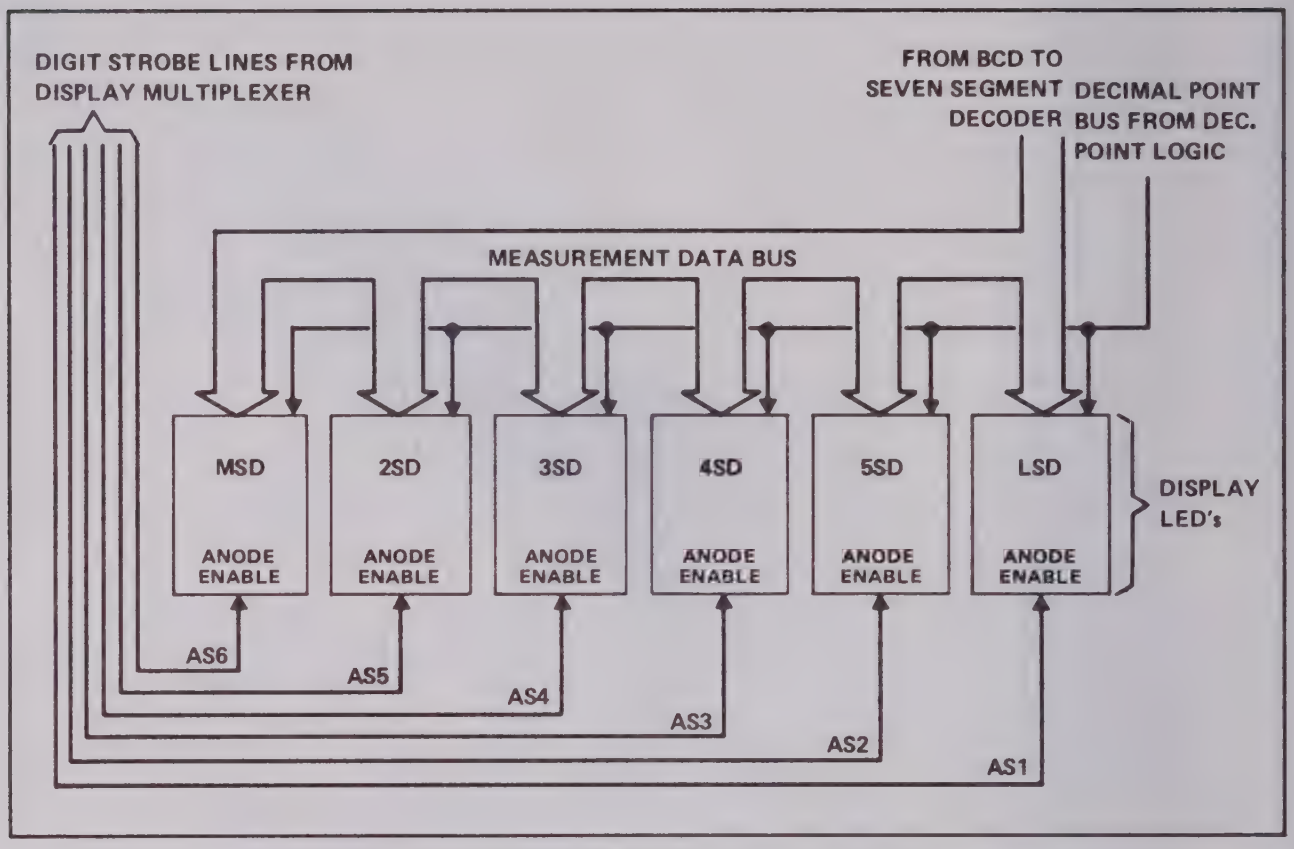


Figure 3-7. DISPLAY SECTION, BLOCK DIAGRAM

output (in modes other than period) or signal output from the input section (period mode) by a selected power of ten to obtain the proper main gate enable signal. The time base dividers are contained within a single integrated circuit which receives division commands from the iteration counter within the range control logic. Table 3-1 lists the eight different combinations of division commands, hereafter called range coding, and the corresponding division factors provided by the dividers for the time base output. For example, an input to the dividers of 1 MHz with a true signal on the RNG2 and false signals on the RNG1 and RNG0 range code lines, the time base output would be 100 Hz and have a period of 10 milliseconds.

3-46. Control Logic

3-47. The control logic, shown in Figure 3-10, controls the sequence of events which take place throughout the counter in order to take a measurement and display it. The control logic sequences through the measurement cycle at a rate controlled by a 100 Hz relaxation-type oscillator. The measurement cycle consists of the following basic steps:

a. A general reset command is issued to initialize the control and autorange logic.

b. The main gate is enabled for a period of time which corresponds to the selected resolution. During this time, the decade counters accumulate the input pulses passed by the main gate. Also, the 100 Hz oscillator and the control logic is inhibited during this time to reduce the amount of electrical noise within the unit during the actual measurement.

c. At the end of the main gate time, the main gate is inhibited and a memory update command (MUP) is issued to load the display memory with the contents of the decade counters when in the manual range mode. In the auto range mode, the measurement will be repeated on the next higher range until the requirements of the autorange logic are met. At that time, the MUP command will be generated.

d. The iteration counter in the autorange logic is reset.

3-48. The following discussion describes the measurement cycle with reference to Figure 3-10. As a starting point, assume the sequencer, comprising a BCD decade counter

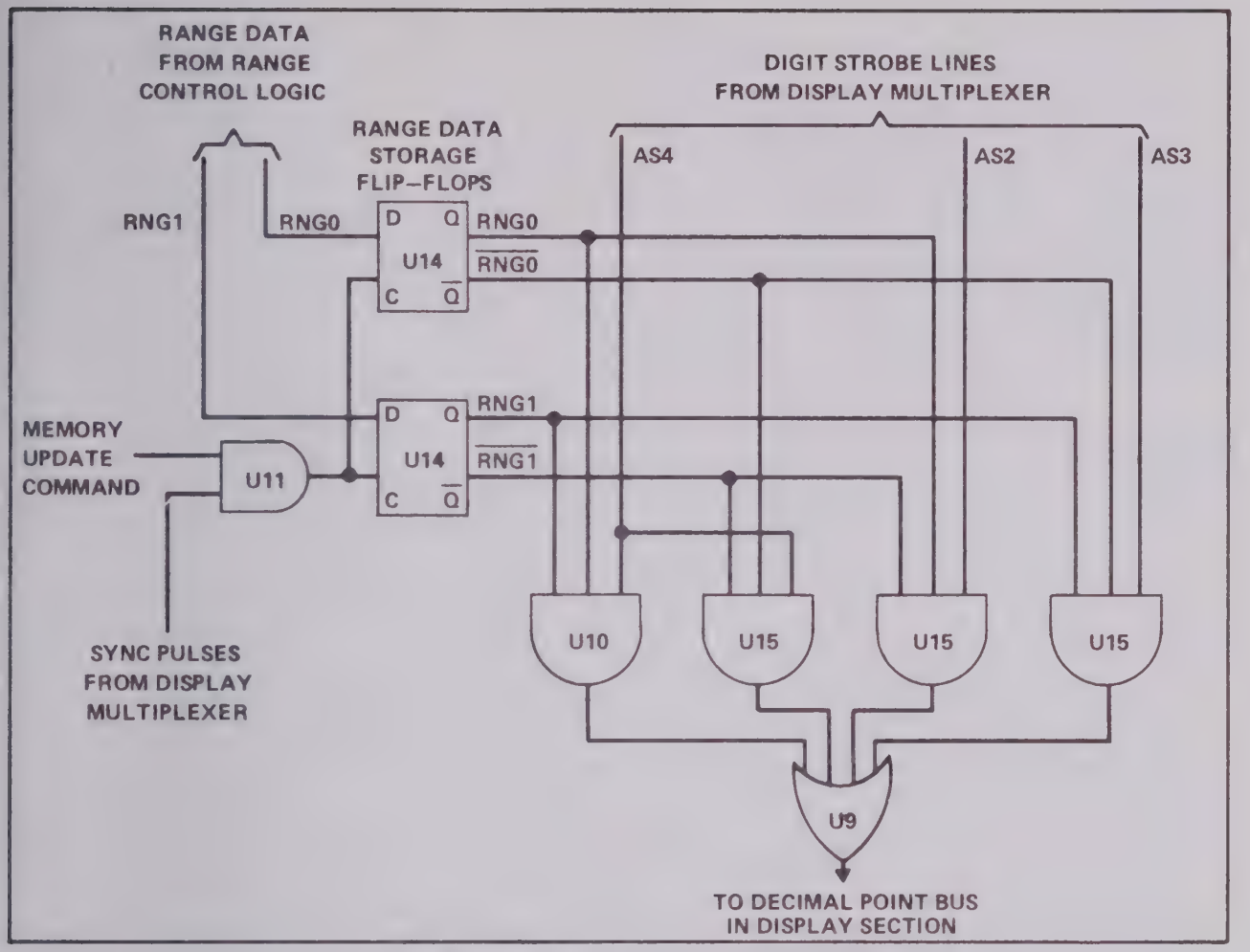


Figure 3-8. DECIMAL POINT LOGIC, BLOCK DIAGRAM

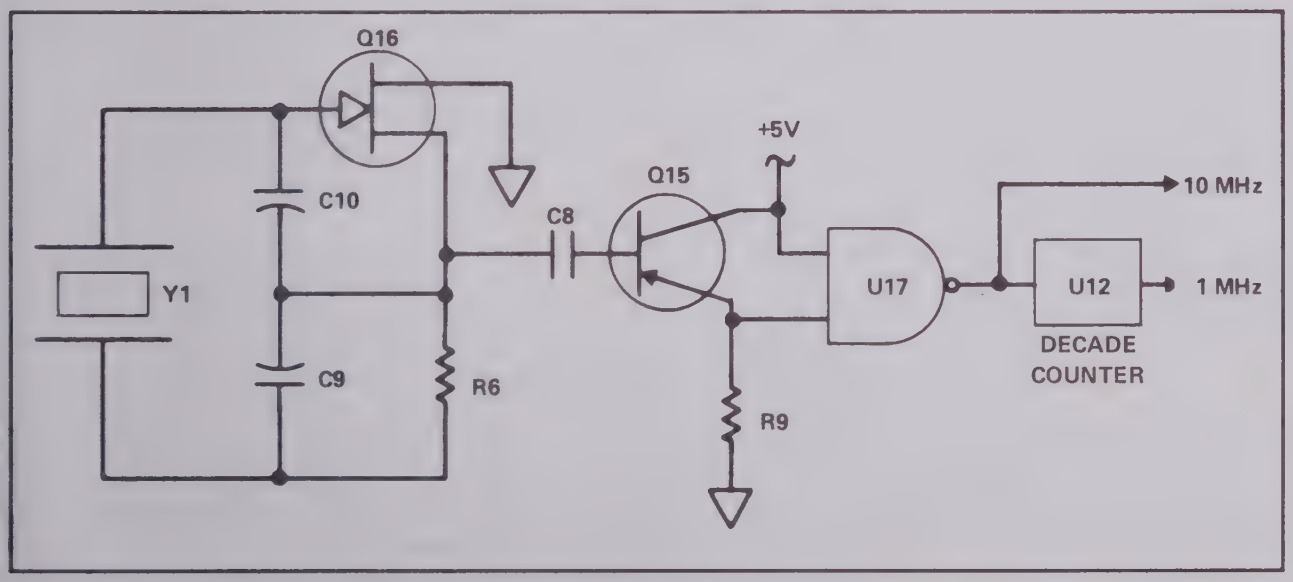


Figure 3-9. TIME BASE OSCILLATOR, BLOCK DIAGRAM

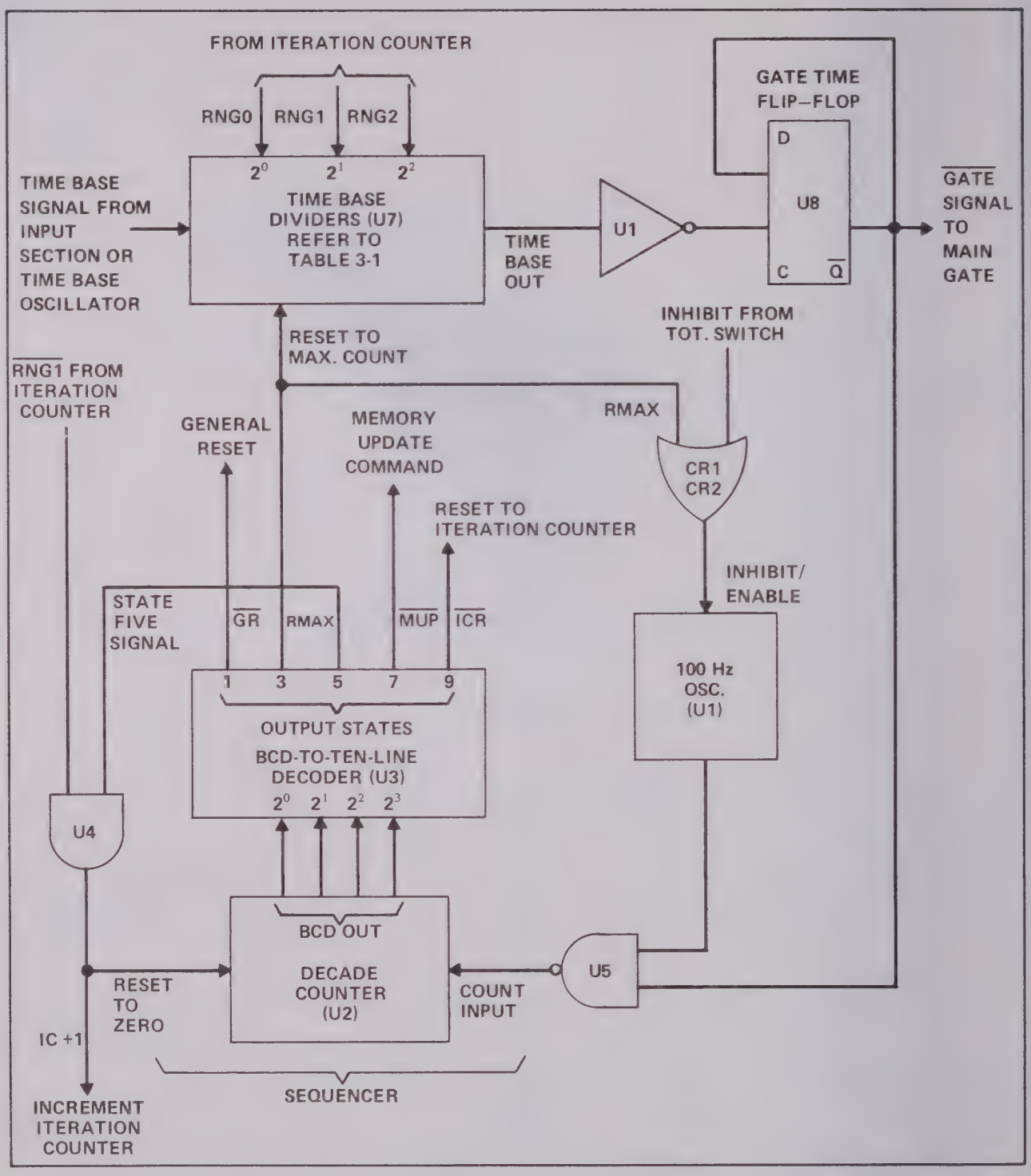


Figure 3-10. TIME BASE DIVIDERS/CONTROL LOGIC, BLOCK DIAGRAM

(U2) and a BCD-to-ten-line decoder (U3) are at count state one (i.e. the 2^0 output of the decade counter is true). State one is a general reset (GR) command which is used to reset the decade counters and the autorange logic. The counter advances to state two, and 10 milliseconds later, to state three.

3-49. For all states of the sequencer, except state three, the state three (RMAX) output is high to reset and hold the time base dividers at maximum count (i.e. 999·), and to enable the 100 Hz oscillator. When the sequencer reaches state three, the time base dividers are allowed to count and will wrap-around to zero upon receipt of the first pulse of

Table 3-1. TIME BASE DIVIDER RATIOS (U7)

RANGE CODE LINES TO U7			Division Factor Input/Output	Front-Panel Selected Resolution/ Periods Averaged
RNG2 (PIN 12)	RNG1 (PIN 13)	RNG0 (PIN 14)		
0	0	0	10^0	10^0
0	0	1	10^1	10^1
0	1	0	10^2	10^2
0	1	1	10^3	10^3
1	0	0	10^4	100Hz
1	0	1	10^5	10Hz
1	1	0	10^6	1Hz
1	1	1	10^7	0.1Hz

time base signal from the time base oscillator or input section (period mode). When the time base counters wrap-around to zero, a leading pulse edge appears at the time base output to set the gate time flip-flop (U8) and enable the main gate. During the time the main gate is enabled, gate U5 is inhibited and the 100 Hz oscillator output is prevented from advancing the sequencer past state three.

3-50. Also during this time, the time base dividers are being allowed to count the input pulses applied to their input. This action continues until the time base dividers reach full-count and then wrap-around to zero again. This action produces a second leading pulse edge at the time base output to toggle the main gate flip-flop (U8) back to the reset state to generate a positive-going pulse edge at its Q output. The positive-going edge inhibits the main gate and is also received at the count input of the sequencer (via gate U5) to advance the counter to the next state (state four). State four resets and holds the time base dividers at maximum count. Since the main gate flip-flop is now reset, Gate U5 is enabled and the 100 Hz pulses are again applied to the count input of the sequencer. Ten milliseconds after advancing to state four, the sequencer advances to state five.

3-51. State five of the sequencer performs functions only when counter operation is in the autorange mode, and only when the autorange logic is still achieving the optimum range. If the autorange logic is still achieving optimum range, a false RNG1 signal from the iteration counter within the autorange logic is present to enable gate U9. The state five output of the sequencer resets its decade counter to zero and issues a pulse (IC + 1 command) to increment the iteration counter within the autorange logic. From the zero state, the 100 Hz oscillator advances the counter to state three to generate the RMAX command and repeat the described sequence.

3-52. When state five of the sequencer is reached with no RNG1 signal from the autorange logic, the sequencer progress to state seven and generates a memory update (MUP) command to the display memory, the decimal point logic and the autorange logic. The MUP command causes the display to be updated to the last measurement. After state seven, state nine resets the iteration counter within the autorange logic back to zero. State one issues a general reset to the decade counters and autorange logic. State three issues the RMAX commands to initiate the next measurement sequence.

3-53. Auto Range Logic

3-54. The function of the autorange logic is to automatically select the highest operating range (longest gate time) without overflowing the display. If the gate time is shorter than necessary, then resolution is lost; and if the gate time is too long, then the most significant digit(s) may be lost due to overflow. The autorange logic automatically selects optimum range for a particular input before allowing the sequencer in the control logic to issue the memory update command. However, the autorange logic will not select the 10 second gate time since it may take the logic as many as three range changes to determine the optimum range, and 11 seconds is too long for the operator to wait for an up-to-date measurement.

3-55. The autorange logic also provides range control hysteresis. That is, the counter will uprange at a certain frequency count, but will not downrange until the frequency count falls well below the uprange point. For example, a frequency count of 999999 on the 1.0 second range is acceptable, but when increased by a single count causes the autorange logic to change to the 0.1 second range and display 100000. If a decrease of a single count (or even a few counts) was allowed to shift the range back to the 1.0 second gate time, then the autorange logic would be constantly upranging and downranging whenever an input signal (near the autorange shift point) had a small amount of frequency modulation or jitter. The result would be unstable display due to the shifting of decimal point and measurement data. To avoid this problem, the autorange logic upranges whenever the count exceeds 999999, and down ranges whenever the count drops to 079999. This hysteresis provides a 20% overlap of frequencies and prevents unnecessary upranging and downranging.

3-56. To follow the action of the autorange logic, refer to Figures 3-11 and 3-12. The autorange logic receives its commands from the sequencer within the control logic, and receives its display information (autorange sense input) from the 2^3 output of the 2SD decade counter, which is

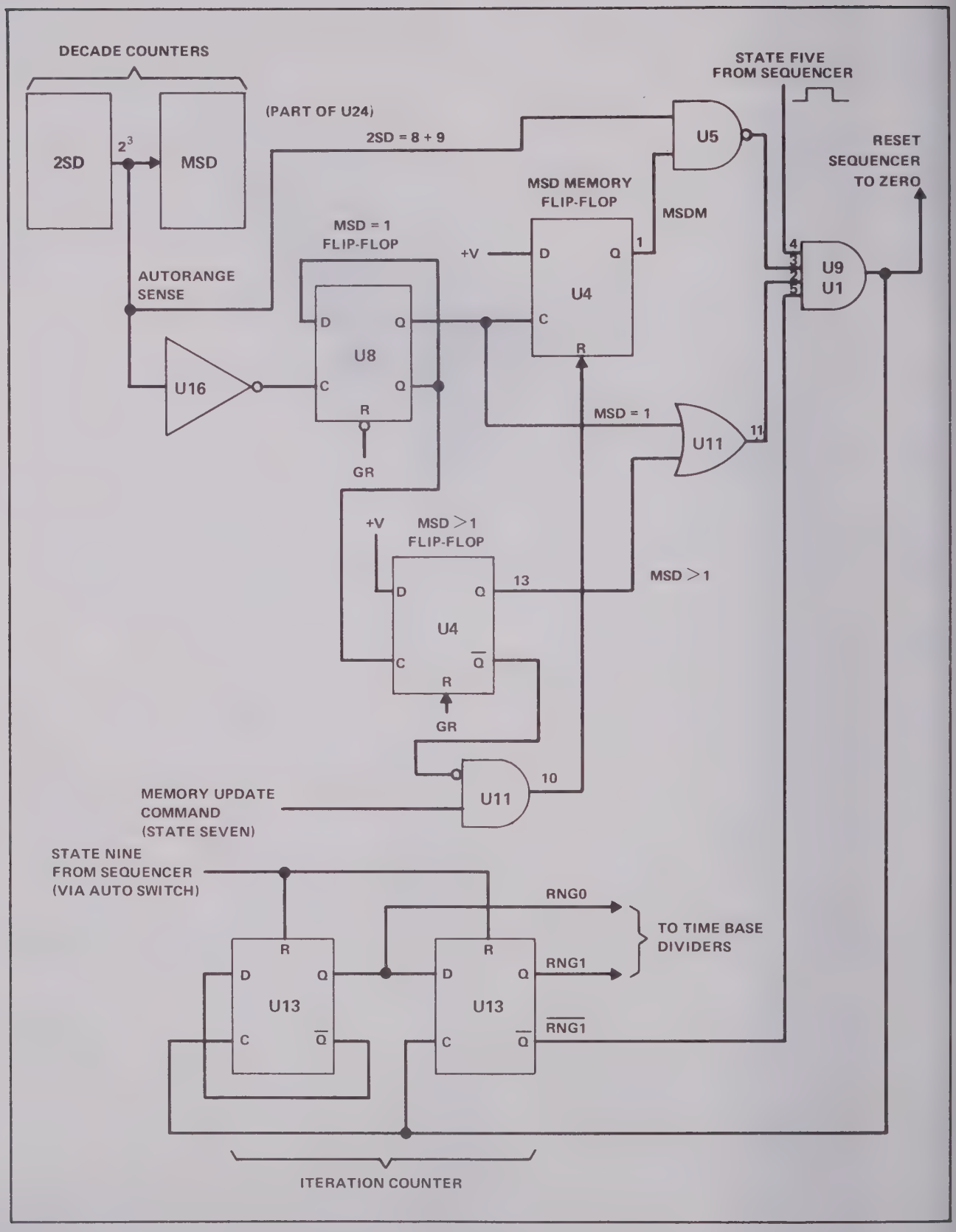


Figure 3-11. AUTORANGE LOGIC, BLOCK DIAGRAM

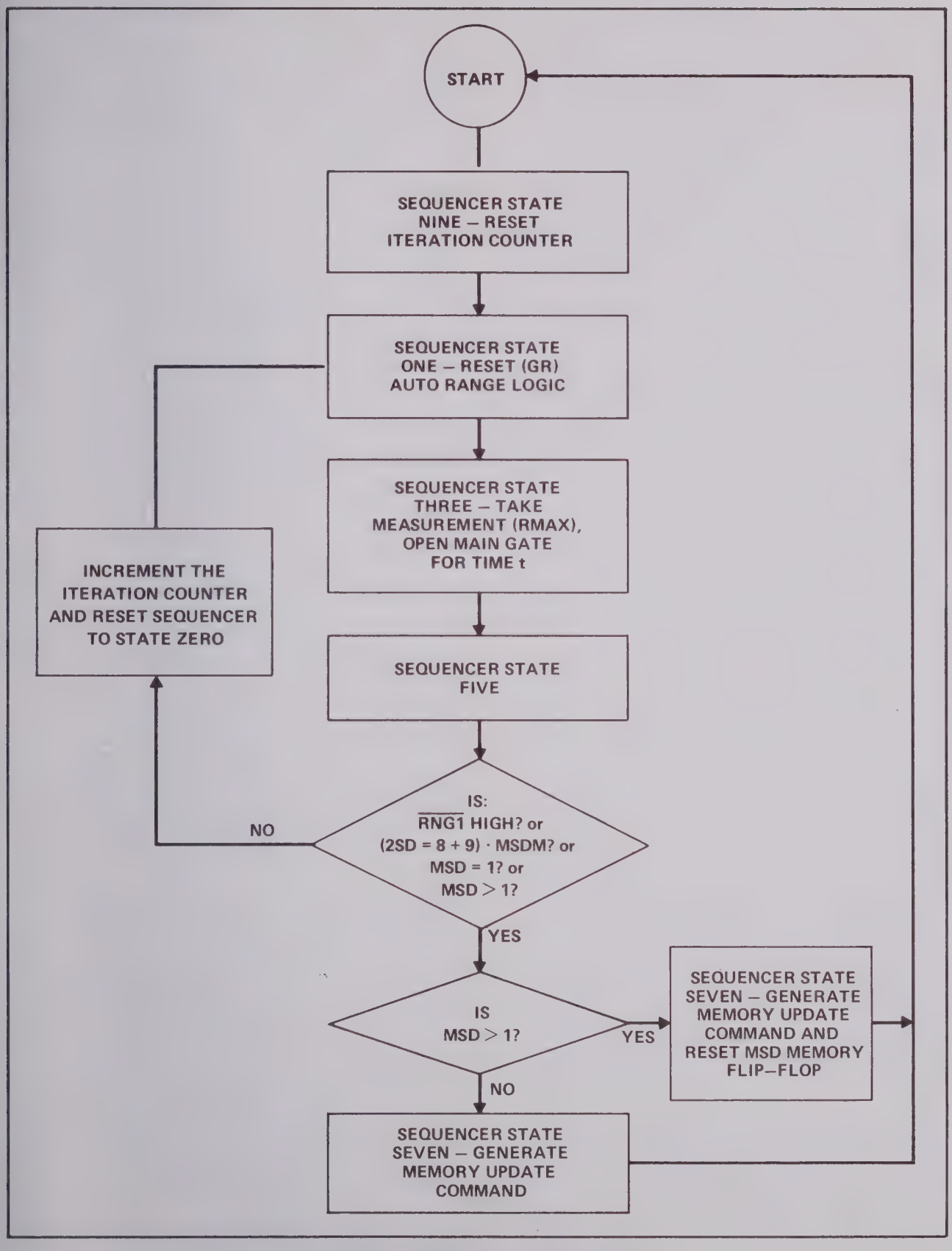

START
SEQUENCER STATE NINE – RESET ITERATION COUNTER
SEQUENCER STATE ONE – RESET (GR) AUTO RANGE LOGIC
SEQUENCER STATE THREE – TAKE MEASUREMENT (RMAX), OPEN MAIN GATE FOR TIME t
SEQUENCER STATE FIVE
IS: RNG1 HIGH? or (2SD = 8 + 9) · MSDM? or MSD = 1? or MSD > 1?
NO
INCREMENT THE ITERATION COUNTER AND RESET SEQUENCER TO STATE ZERO
YES
IS MSD > 1?
YES
SEQUENCER STATE SEVEN – GENERATE MEMORY UPDATE COMMAND AND RESET MSD MEMORY FLIP–FLOP
NO
SEQUENCER STATE SEVEN – GENERATE MEMORY UPDATE COMMAND

Figure 3-12. AUTORANGE LOGIC FLOW CHART

also the carry line to the MSD decade counter. This line goes true whenever the 2SD decade counter achieves a count of eight, and goes false to provide a trailing edge whenever the 2SD exceeds a count of nine and increments the MSD decade counter to a count of one or greater.

3-57. Initially, the iteration counter (which controls the time base dividers, and consequently determines the operating range) is reset to zero by the state nine output of the sequencer. In the zero state, the RNG 0 and RNG1 outputs are false or low, and the iteration counter selects the 0.01 second range. When the sequencer advances to the one state, a general reset (GR) command is generated to reset the MSD=1 and MSD < 1 flip-flops shown in Figure 3-11.

3-58. When the sequencer reaches state three, the previously described measurement cycle begins to enable the main gate, load the decade counters, inhibit the main gate, etc. The sequencer then advances to state five. Depending upon conditions at the other three inputs of AND gate U9 (shown in Figure 3-11), the state five output of the sequence will be (1) used to reset the sequencer back to the zero state and increment the iteration counter, of (2) will be ignored so that the sequencer can proceed to state seven to generate the memory update command and load the previous measurement data from the decade counters into the display memory.

3-59. Assume that at the end of the gate time, the contents of the decade counters was 012345, where zero is the MSD. The sequencer advances to state five, and the state five signal is passed by the four-input AND gate (formed by U9 and U1). The gate is enabled since the $\overline{\text{RNG1}}$ signal went high when the iteration counter was previously reset; 2SD = 8 + 9 is low due to no 8 or 9 in the 2SD decade counter; and none of the flip-flops have gone set due to no trailing edges appearing on the autorange sense line. (Trailing edges appear on the autorange sense line only when the MSD decade counter is incremented). Since none of the conditions are met to inhibit gate U9, the five output increments the iteration counter and resets the sequencer to the zero state to begin the next iteration. With the iteration counter incremented to its next state, the next range (0.1 second) is automatically selected.

3-60. As a result of the same measurement on the 0.1 second range, the contents of the decade counters is now 12345x, where 1 is the MSD. Since there is now an MSD, there has been a trailing edge on the autorange sense line to set the MSD = 1 and MSD < 1 flip-flops. The output of the MSD = 1 flip-flop inhibits the AND gate (U9) and causes state five of the sequencer to be ignored. The sequencer then proceeds to state seven to generate the memory update command to update the display with the measurement taken on the 0.1 second range. The sequencer then progresses to state nine to reset the iteration counter and begin the entire autorange sequence over again starting with the lowest range (0.01 second).

3-61. If the frequency of the input signal is decreased, or the period is decreased, so that the contents of the decade counters become less than 100000 (i.e. they drop to some value between 099999 and 080000), the autorange logic will prevent a downrange shift until the counters drop to 079999 or below. For example, assume the counter's contents drop from 12345x to 099999. The MSD = 1 flip-flop remains reset as a result of the GR signal of sequencer state one; the MSD < 1 flip-flop remains set since the GR signal has no effect; the MSD > 1 flip-flop never got set; and the 2SD = 8 + 9 signal is high due to the 9 present in the 2SD decade counter. The high MSDM and 2SD = 8 + 9 signals inhibit the AND gate U9 and prevent the state five output of the sequencer from incrementing the iteration counter and resetting the sequencer to zero. Since the sequencer is not reset, it is allowed to progress to state seven to generate the memory update command, etc.

3-62. When the signal under measurement changes so that the decade counters contain 079999 or less at the end of the measurement, conditions within the autorange logic are the same as with 099999 in the decade counters, except for the 2SD = 8 + 9 line, which is now low due to a 7 (or less) in the 2SD decade counter. As a result, the AND gate U9 is enabled, and sequencer state five increments the iteration counter to produce the 1.0 second range,and the sequencer is reset to zero to repeat the measurement on the new range without updating the display at this time.

3-63. At the end of the 1.0 second measurement, the decade counters contain 79999x. At the time of state five, the MSD > 1 flip-flop is set to inhibit AND gate U9. ($\overline{\text{RNG1}}$ is also high to inhibit AND gate, but would not be if the contents of the decade counters had been ten times greater and the autoranging had ceased at the 0.1 second range.) With the AND gate inhibited, state five is ignored. State seven issues the memory update command to enter the new measurement into the display memory. The memory update command resets the MSD memory flip-flop due to the set state of the MSD < 1 flip-flop. The remainder of the autorange logic is reset by states nine and one of the sequencer.

3-64. The preceeding paragraphs describe the downranging action of the autorange logic when the input fre-

quency to the decade counters decreases from 12345x to 099999 to 799999, with the range change point being 080000/799999. Upranging action is similar, but takes place at the 999999/10000 point instead of the 799999/080000 point. When the signal under measurement changes so that the decade counters increase from 799999 to 800000, the autorange logic recognizes no change other than the 2SD = 8 + 9 line which is now low. However, U9 is still not enabled due to the setting of the MSD > 1 flip-flop due to the 8 in the MSD decade counter. As a result, state five is ignored and state seven issues the memory update command, etc. When the signal under measurement changes so that the contents of the decade counters increase from 999999 to 100000, the logic upranges to the next shortest gate time in order to avoid a display of 000000 plus overflow.

NOTE

It should be kept in mind that the autorange logic, by means of the iteration counter, always begins a measurement cycle with the shortest gate time, and steps up (never down) to the optimum gate time.

3-65. Manual Range Control

3-66. When the counter is not in the autorange mode, it is in the manual range control mode. Manual selection of the different ranges is achieved by using the front-panel RESOLUTION/PER AVGD switches to override the resetting and incrementing action of the iteration counter, which in turn programs the time base dividers in accordance with its particular state. The front-panel switches force the iteration counter to one of its four states and hold it there until either another RESOLUTION/PER AVGD switch is closed, or the autorange function is selected. During manual range control mode, the autorange logic is inhibited by the MSD > 1 flip-flop, which is held in its set state by the selection of the front-panel RESOLUTION/PER AVGD switches. (Refer to the schematic diagram, 1900A–1001 sheet 2 of 3.)

Section 4
Maintenance

4-1. INTRODUCTION

4-2. This section contains information concerning preventive and corrective maintenance for the Model 1900A Multi-Counter. A maintenance interval of one year for calibration is recommended to ensure instrument operation within the one year specifications. Equipment for performing maintenance tests and adjustments is listed in Table 4-1. If this equipment is not available, other equipment having equivalent specifications may be used.

NOTE

When greater than one year accuracy is required, refer to specifications for timebase aging rate to determine the re-calibration interval required to maintain desired accuracy.

4-3. SERVICE INFORMATION

4-4. Should your instrument need repair, send it to the nearest factory authorized service center. A list of these authorized service centers is located on the inside of the front cover. Also located on the inside front cover is the WARRANTY which warrants the instrument for a period of one year.

4-5. GENERAL MAINTENANCE

4-6. Access

4-7. Use the following procedure to gain access to the interior of the Model 1900A.

a. With the power switch OFF, disconnect the line cord.

b. Remove the Phillips screw at the rear of the instrument case.

c. Remove the instrument from the case.

4-8. Cleaning

4-9. Clean the front panel and case with denatured alcohol or mild solution of detergent and water. Do not use aromatic hydrocarbons or chlorinated solvents because they will react with the plastic materials of the instrument.

4-10. Fuse Replacement

4-11. The input power fuse, F1, is located within the instrument in a fuse clip near the power transformer (T1). To gain access to the fuse, refer to paragraph 4-6. When replacement is required, install AGC 1/8A (fast acting) for line powered instruments. Use MDA ½A (slow blow) for battery powered instruments.

4-12. Battery Replacement (Option 1900A–01)

4-13. Follow the disassembly instructions below for removing the replaceable batteries in the Model 1900A–01.

CAUTION

Damage may result if alkaline, zinc-carbon or mercury batteries are charged.

a. Disconnect line cord. Remove retaining screw at rear of instrument case, and remove instrument from case.

b. On the underside of the PCB, remove the two threaded bolts securing the battery holders.

Table 4-1. TEST EQUIPMENT REQUIRED FOR PERFORMANCE TEST, CALIBRATION AND TROUBLESHOOTING

EQUIPMENT NOMENCLATURE	RECOMMENDED MODEL	WHERE USED
Quartz Oscillator Frequency Standard with 10 MHz Output		Timebase Oscillator Adjustment
Low-Frequency Oscillator	HP204D	
High-Frequency Oscillator	HP8654A	
RF millivoltmeter with 50Ω terminator	Boonton 91C	Sensitivity Check
Multimeter	Fluke 8000A	Troubleshooting
Oscilloscope	Tek 465	Troubleshooting

c. Remove the holder tops and batteries.

d. Replace the batteries with 1.2 volt nickel-cadmium batteries (JF Part No. 346924). Install the batteries in the polarity indicated on the battery holder.

4-14. PERFORMANCE CHECKS

4-15. The performance checks provide a means of verifying overall operation of the Model 1900A. The checks can be used as an acceptance check during incoming inspection or as a periodic maintenance check. Refer to Table 4-1 for a list of required test equipment. Equivalent equipment may be used.

4-16. Functional Check

4-17. To perform a functional check of the Model 1900A, refer to the self-check described in Section 3.

4-18. Sensitivity Check

4-19. Perform the sensitivity checks as follows:

a. Connect the low frequency generator, set for 5 Hz at 25mV, to the 1900A input.

b. Energize the counter and depress the FREQ function switch and AUTO resolution switch.

c. Confirm that the counter display indicates .005 kHz ± 1 digit.

d. Disconnect the low frequency generator from the input.

e. Connect the high frequency generator, terminated into 50 ohms, to a T-connector on the 1900A input. Set the generator output for 10 MHz at approximately 25mV rms.

g. Connect the RF millivolt meter to the T-connector on the input of the 1900A.

h. Adjust the high frequency generator output for a reading of exactly 25mV on the RF millivolt meter.

i. Confirm that the counter display indicates 10.0000 MHz ± generator accuracy.

j. Change the generator output to 80 MHz at exactly 25mV.

k. Confirm that the counter display indicates 80.0000 MHz ± generator accuracy.

4-20. CALIBRATION

4-21. Calibration of the Model 1900A is limited to adjustment of the trigger level and time base oscillator frequency.

4-22. Trigger Level Adjustment

4-23. Trigger level adjustment should be performed whenever repairs have been made to the input section of the counter. The input section comprises that circuitry contained on the input printed circuit board assembly. Perform trigger level adjustment as follows:

a. Remove the counter from the case (paragraph 4-6)

b. Energize the counter and connect the high-frequency oscillator to the counter input.

c. Select an output of 25 mV rms at approximately 80 MHz on the oscillator.

d. Adjust the trigger level control (R14) to a mid-point which produces a stable display near 80 MHz.

e. Reduce the signal level until the display becomes unstable.

f. Re-adjust the trigger level control until the display is again stable.

g. Repeat steps e and f until no additional sensitivity increase is possible.

4-24. Time-Base Oscillator Adjustment

4-25. Time base oscillator adjustment should be made whenever the oscillator is repaired, or whenever it is determined that accuracy of the counter is not within the accuracy desired. Perform time base oscillator adjustment in an environment having an ambient temperature of +22°C to +25°C (72°F to 77°F).

4-26. The time base oscillator output frequency can be accurately set using either of the two methods given. The first method, using a frequency standard for the reference, should be used whenever a standard is available. The second method uses the WWV broadcast frequency as the calibration standard, and may be used whenever a suitable frequency standard is not available.

4-27. TIME BASE ADJUSTMENT USING A FREQUENCY STANDARD

a. Remove the counter from the case (paragraph 4-6)

b. Energize the counter and select the FREQ function and 10 Hz resolution.

c. Select a 10 MHz output on the quartz oscillator and connect the 10 MHz signal to the counter input.

d. While observing the counter display, adjust the time base oscillator control (C11 located on the main pcb directly behind the reset switch) to obtain a reading of 000000 ± 1 digit.

4-28. TIME BASE ADJUSTMENT USING WWV

4-29. This procedure requires the counter to be in close proximity to the receiver antenna lead-in cable.

a. Remove the outer cover of the 1900A counter.

b. Tune the SW receiver to the 10 MHz WWV broadcast.

c. Bring the 1900A near enough to the SW receiver antenna lead so that a zero beat note can be heard on the receiver speaker. If insufficient radiation is picked up from the counter, turn the time base oscillator towards the antenna and move it in close.

d. Tune the 1900A timebase oscillator adjust for a "zero beat" on the receiver.

e. Look at the receiver signal level meter, and adjust the time base for an exact null. This will put the timebase oscillator output frequency within 1 Hz of the 10 MHz requirement.

4-30. TROUBLESHOOTING

4-31. The following information is designed to aid in troubleshooting the Model 1900A. Fault isolation is achieved by executing the self-check described in Section 2 and noting failure symptoms. Figures 4-2 through 4-6 list several failure sumptoms and their possible causes. Use these figures as troubleshooting guides in conjunction with the theory of operation presented in Section 3. Use Figure 4-1 to locate the test points on the main printed circuit board assembly.

4-32. REPAIR TECHNIQUES

4-33. Battery-Powered Instruments

4-34. In battery-powered instruments, one of the batteries should be removed before attempting any repair. This is necessary to eliminate the danger of shorting portions of the circuitry which carry the battery voltage. Remove the battery as described in paragraph 4-14.

4-35. Integrated Circuit Replacement

4-36. Three types of integrated circuits are used in the Model 1900A, as listed in Table 4-2, and the handling of TTL types require no special handling. However, the

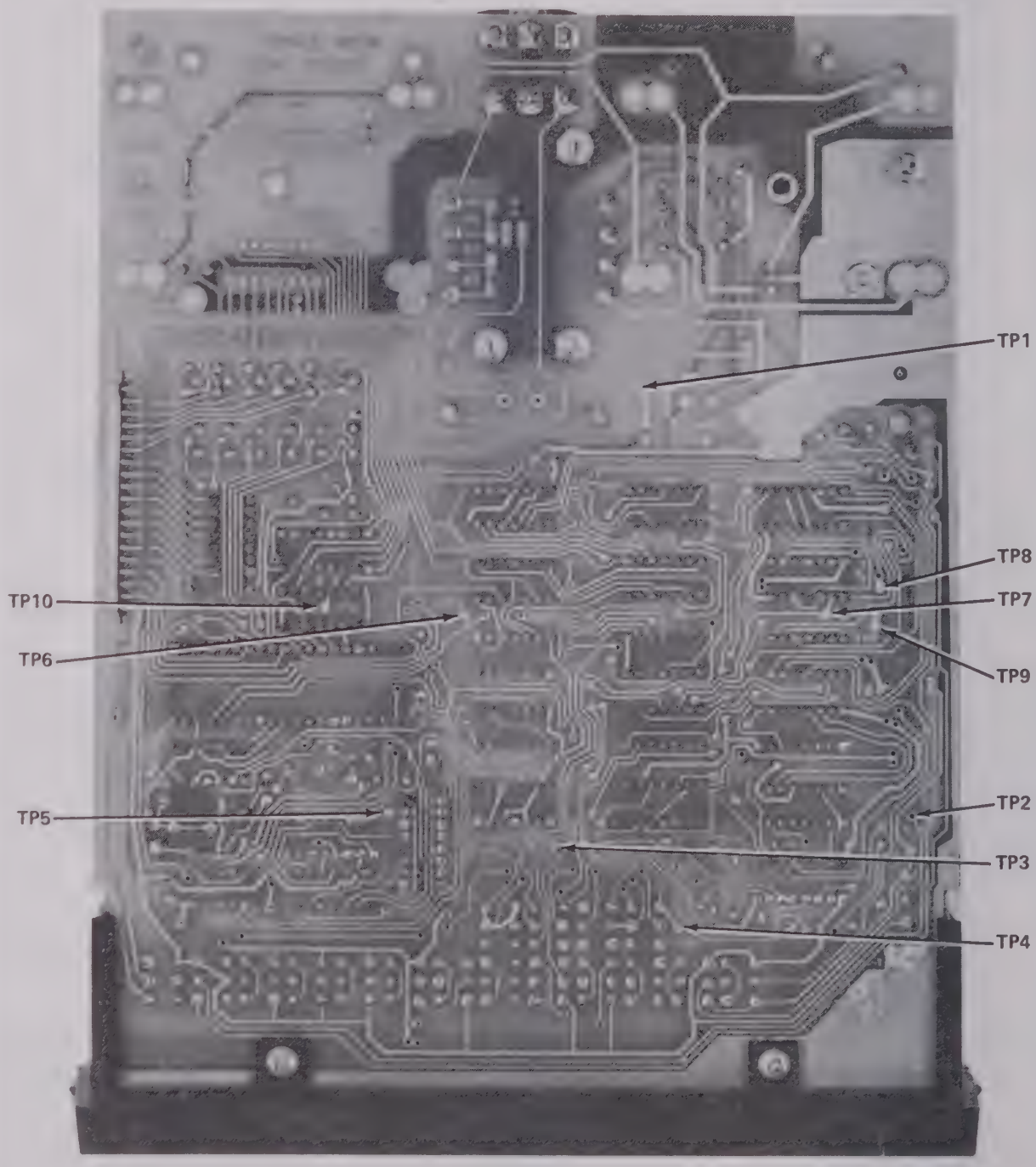


Figure 4-1. TEST POINT LOCATIONS

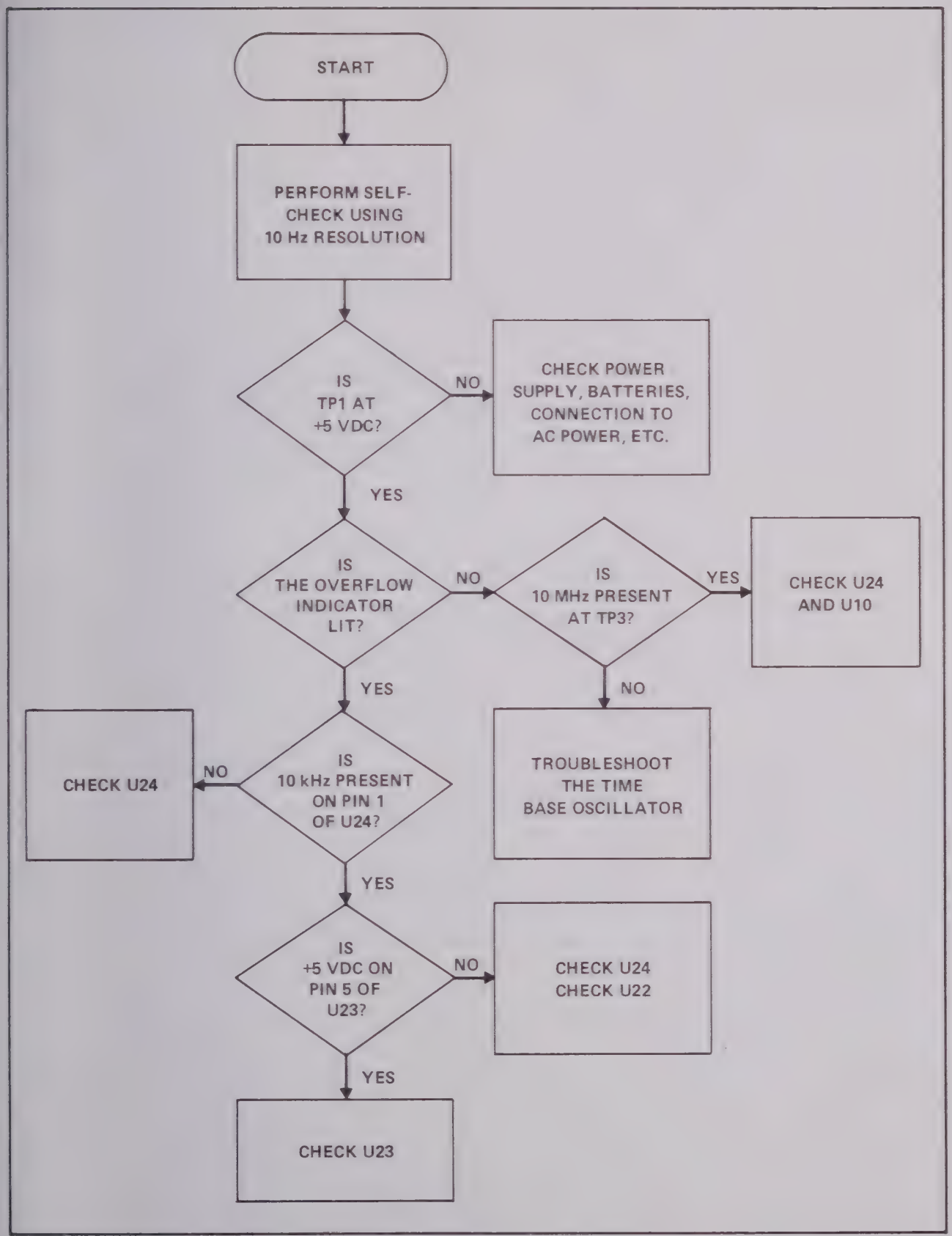


Figure 4-2. FAULT ISOLATION – NO DISPLAY

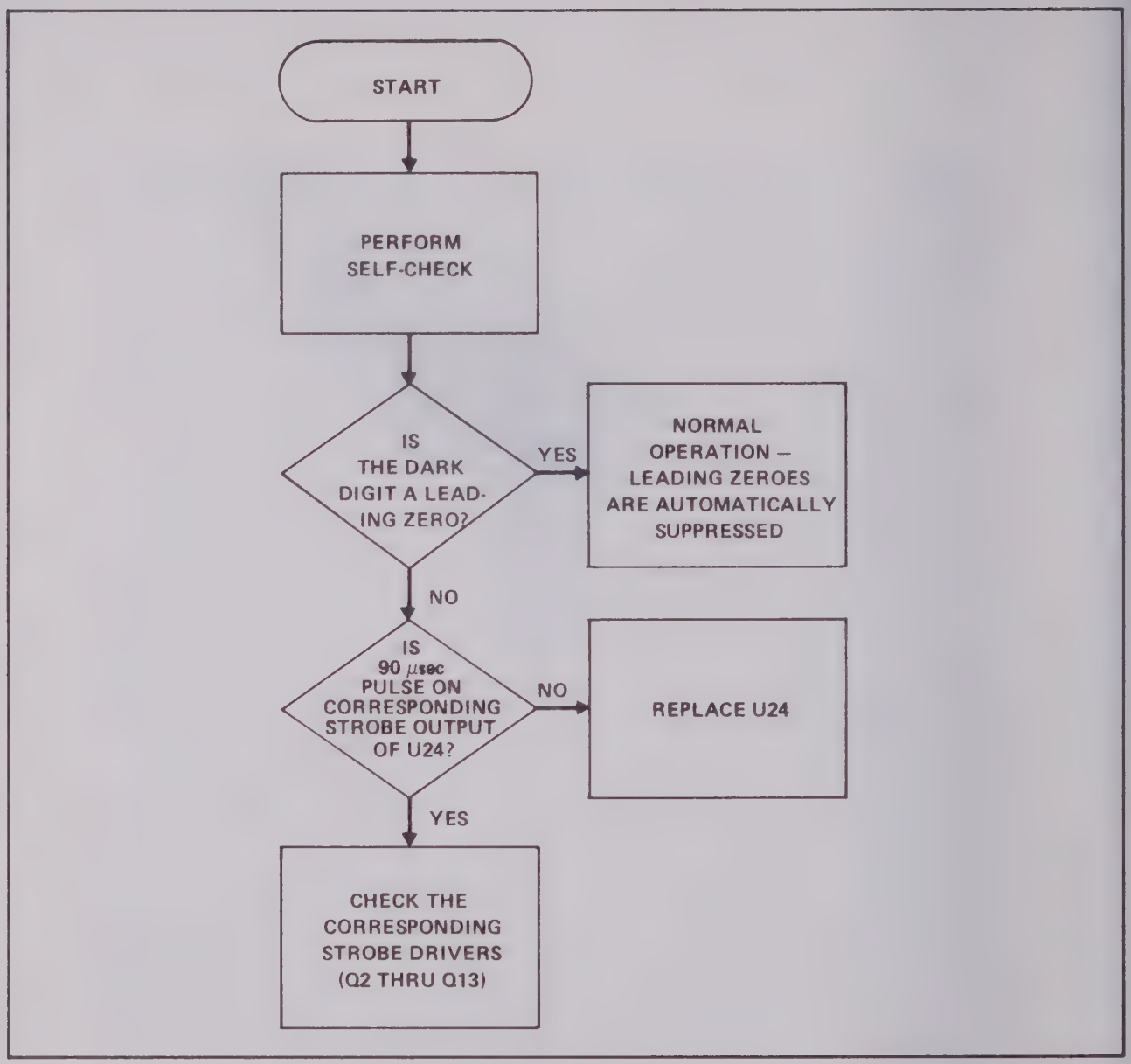


Figure 4-3. FAULT ISOLATION – ONE DARK DIGIT

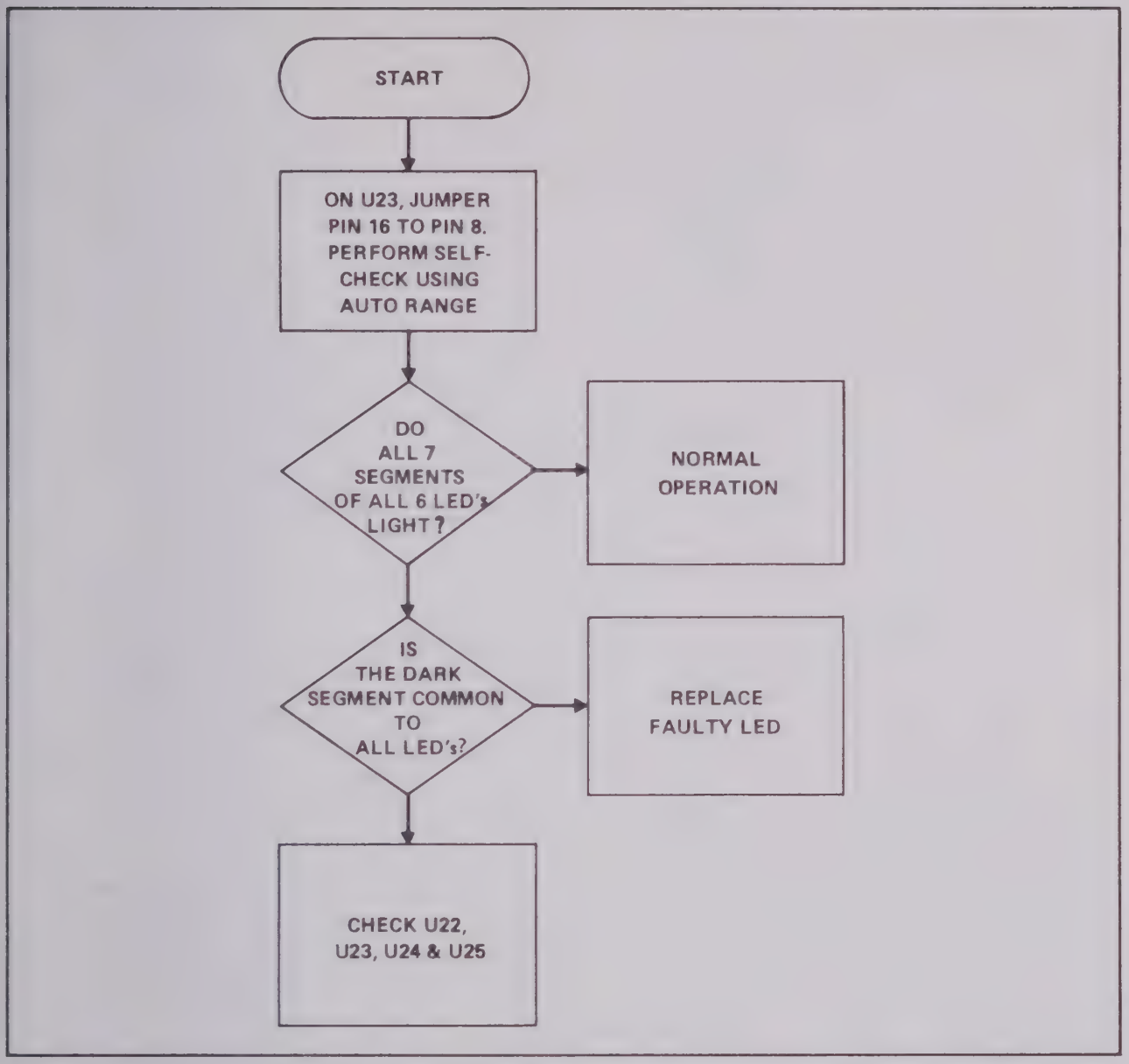

START
ON U23, JUMPER PIN 16 TO PIN 8. PERFORM SELF-CHECK USING AUTO RANGE
DO ALL 7 SEGMENTS OF ALL 6 LED's LIGHT?
NORMAL OPERATION
IS THE DARK SEGMENT COMMON TO ALL LED's?
REPLACE FAULTY LED
CHECK U22, U23, U24 & U25

Figure 4-4. FAULT ISOLATION – DARK LED SEGMENT

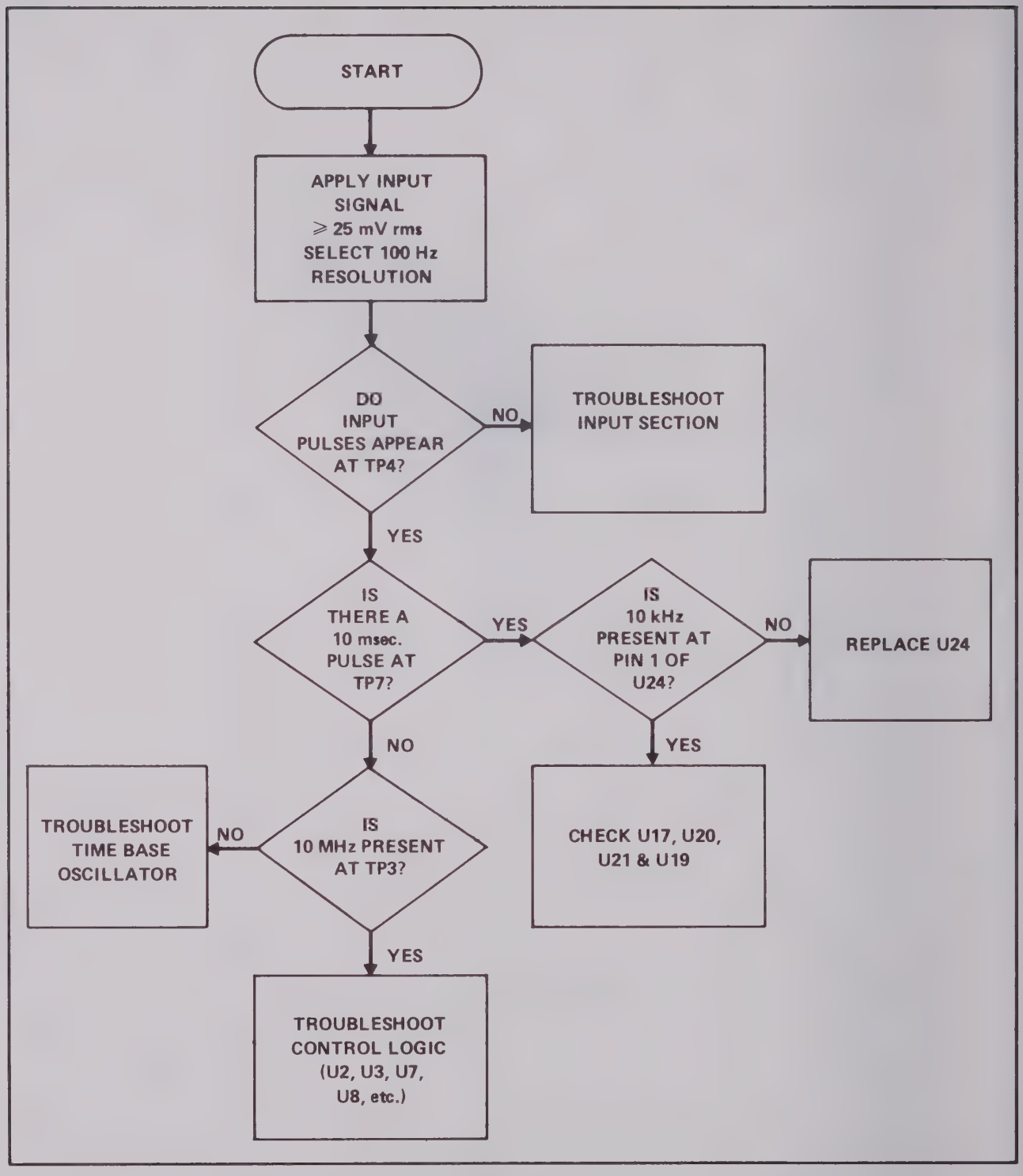


Figure 4-5. FAULT ISOLATION – NO COUNTING ACTION

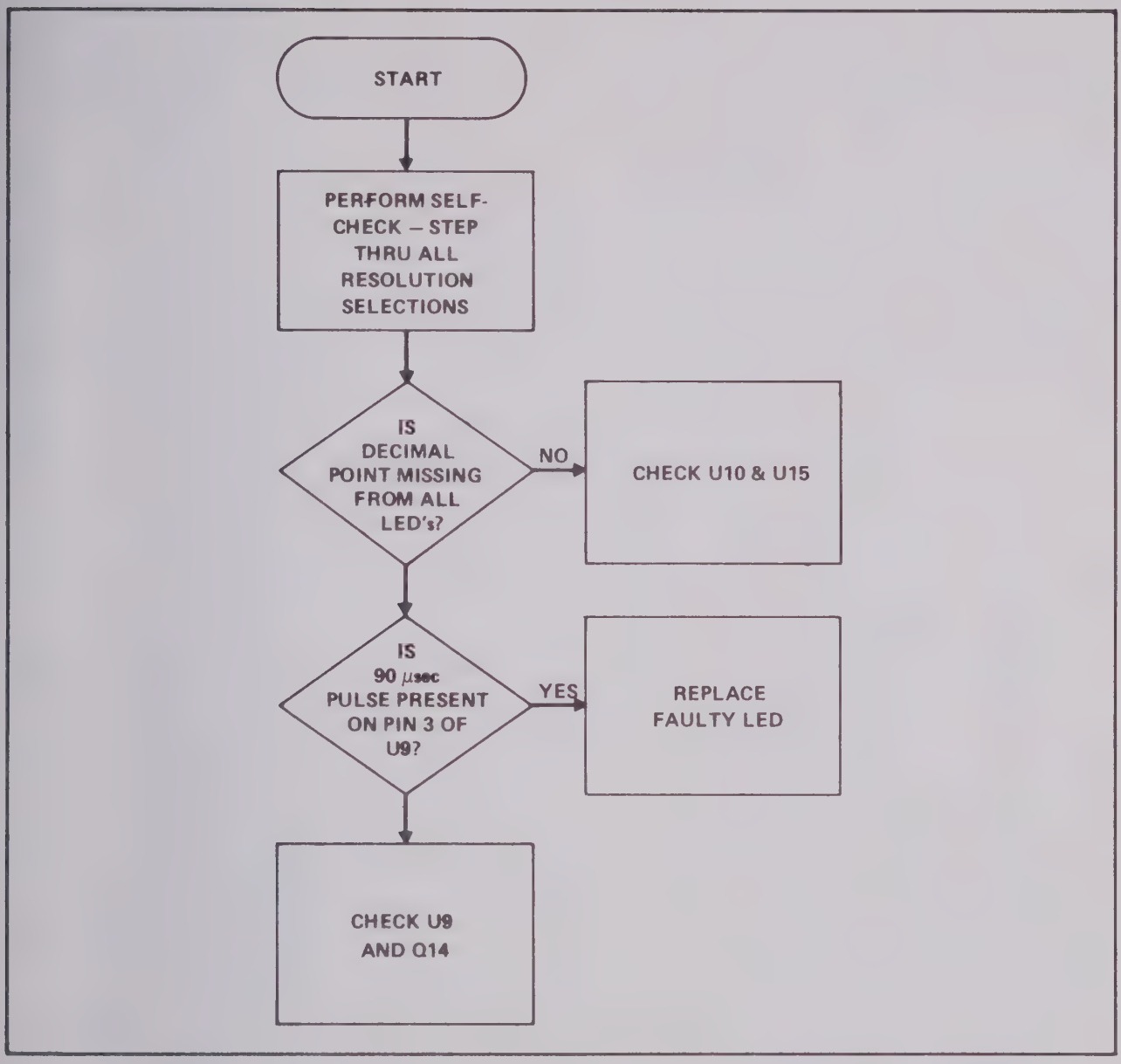

START
PERFORM SELF-CHECK – STEP THRU ALL RESOLUTION SELECTIONS
IS DECIMAL POINT MISSING FROM ALL LED's?
NO
CHECK U10 & U15
IS 90 μsec PULSE PRESENT ON PIN 3 OF U9?
YES
REPLACE FAULTY LED
CHECK U9 AND Q14

Figure 4-6. FAULT ISOLATION – DECIMAL POINT MISSING

CMOS and PMOS types can be destroyed by a static electricity discharge. To prevent damage due to static discharge, the following precautions should be taken whenever this type of integrated circuit is handled:

a. The PMOS or CMOS integrated circuit is packed in conductive foam. Do not remove the conductive foam from the integrated circuit until ready for installation into the unit.

b. Be sure the repairing personnel and the unit under repair are commonly grounded.

c. Be sure the soldering iron used is grounded to the common ground.

Table 4-2. MODEL 1900A INTEGRATED CIRCUIT TYPES.

REFERENCE DESIGNATOR	TYPE	REFERENCE DESIGNATOR	TYPE	REFERENCE DESIGNATOR	TYPE
U1	CMOS	U10	CMOS	U19	TTL
U2	TTL	U11	CMOS	U20	TTL
U3	TTL	U12	TTL	U21	TTL
U4	CMOS	U13	CMOS	U22	CMOS
U5	CMOS	U14	CMOS	U23	TTL
U6	CMOS	U15	CMOS	U24	PMOS
U7	PMOS	U16	CMOS	U25	R
U8	TTL	U17	TTL		
U9	CMOS	U18	CMOS		

Section 5
Lists of Replaceable Parts

TABLE OF CONTENTS

ASSEMBLY NOMENCLATURE	PART NO.	PAGE
Final Assembly	1900A	5-3
Main PCB Assembly, Line Configuration	385021	5-5
Main PCB Assembly, Battery Configuration	378083	5-5
Input PCB Assembly	378125	5-11
Display PCB Assembly	378109	5-14
Inverter PCB Assembly	388447	5-15

5-1. INTRODUCTION

5-2. This section contains an illustrated parts breakdown of the instrument. Components are listed alphanumerically by assembly. Electrical components are listed by item number. Each listed part is shown in an accompanying illustration.

5-3. Parts lists include the following information:

a. Reference Designation or Item Number.

b. Description of each part.

c. Fluke Stock Number.

d. Federal Supply Code for Manufacturers. (See Appendix A for Code-to-Name list.)

e. Manufacturer's Part Number or Type.

f. Total Quantity per assembly or component.

g. Recommended Quantity: This entry indicates the recommending number of spare parts necessary to support one to five instruments for a period of two years. This list presumes an availability of common electronic parts at the maintenance site. For maintenance for one year or more at an isolated site, it is recommended that at least one in each assembly in the instrument be stocked. In the case of optional subassemblies, plug-ins, etc., that are not always part of the instrument, or are deviations from the basic instrument mode, the REC QTY column lists the recommended quantity of the item in that particular assembly.

h. Use Code is provided to identify certain parts that have been added, deleted or modified during production of the instrument. Each part for which a use code has been assigned may be identified with a particular instrument serial number by consulting the Use Code Effectivity, paragraph 5-7.

5-4. HOW TO OBTAIN PARTS

5-5. Components may be ordered directly from the manufacturer by using the manufacturer's part number, or from the John Fluke Mfg. Co., Inc. factory or authorized representative by using the FLUKE STOCK NUMBER. In the event the part you order has been replaced by a new or improved part, the replacement will be accompanied by an explanatory note and installation instructions, if necessary.

5-6. To ensure the prompt and efficient handling of your order, include the following information:

a. Quantity.

b. FLUKE Stock Number.

c. Description.

d. Reference Designation or Item Number.

e. Printed Circuit Board Part Number.

f. Instrument Model and Serial number.

5-7. USE CODE EFFECTIVITY LIST

USE CODE	SERIAL NUMBER EFFECTIVITY

FINAL ASSEMBLY

REF DESIG OR ITEM NO.	DESCRIPTION	FLUKE STOCK NO.	MFG FED SPLY CDE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	USE CDE
	FINAL ASSEMBLY **Figure 5-1.**	1900A	89536				
	Main PCB Assembly, Line Configuration (See Figure 5-2)						
	Main PCB Assembly Battery Configuration (See Figure 5-3)						
	Input PCB Assembly (See Figure 5-4)						
	Display PCB Assembly (See Figure 5-5)						
	Inverter PCB Assembly (See Figure 5-6)						
	Case, molded plastic	330076	89536	330076	1		
	Decal, front panel	381434	89536	381434	1		
	Decal, knob	347401	89536	347401	2		
	Handle, molded	330092	89536	330092	1		
	Lens, red plastic	384701	89536	384701	1		
	Line Cord	343723	89536	343723	1		
	Pad, foot	338632	89536	338632	2		
	Panel, front molded	378067	89536	378067	1		

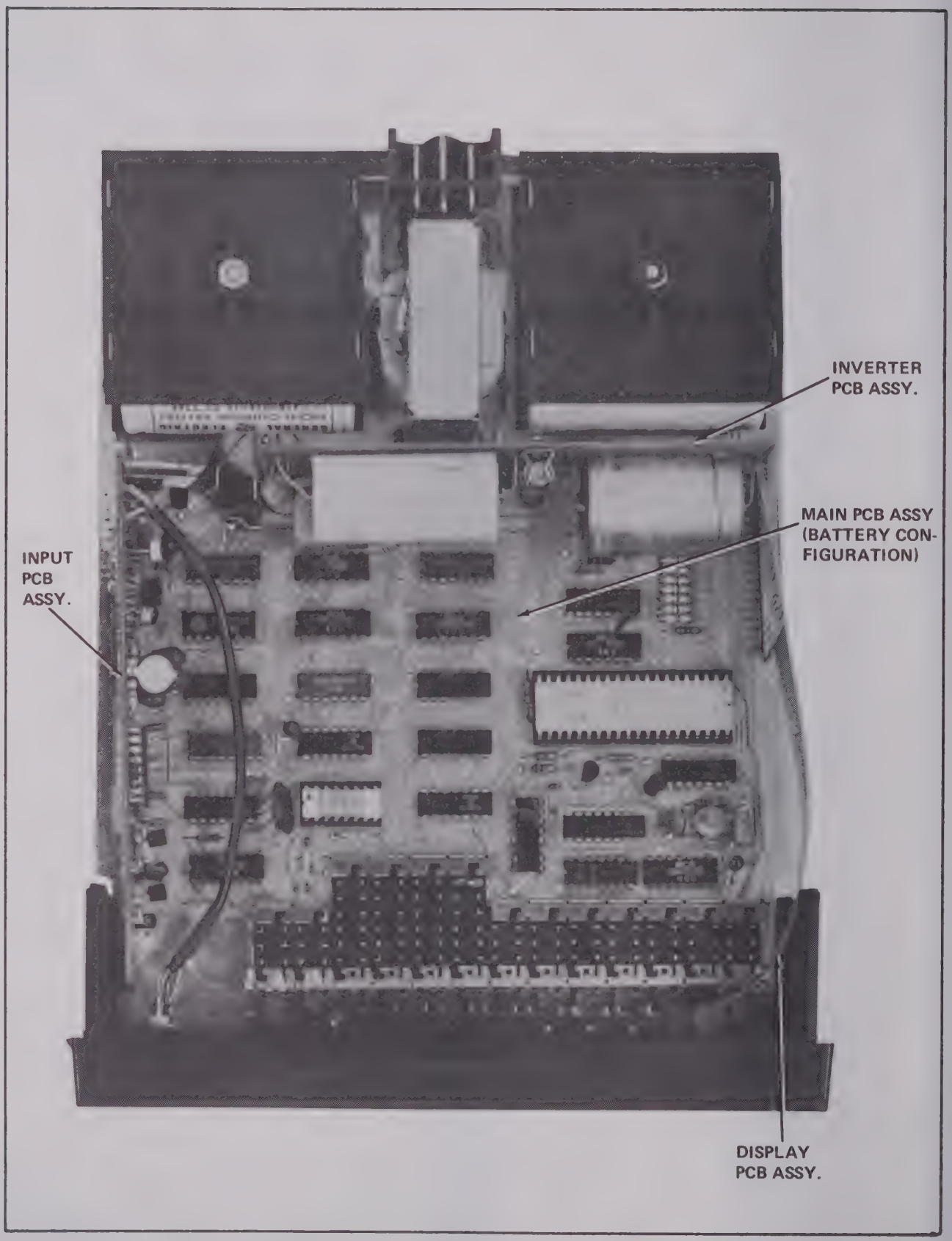


Figure 5-1. FINAL ASSEMBLY

MAIN PCB ASSEMBLY LINE

REF DESIG OR ITEM NO.	DESCRIPTION	FLUKE STOCK NO.	MFG FED SPLY CDE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	USE CDE
	MAIN PCB ASSEMBLY LINE 1 Figure 5-2	385021	89536	385021	REF		
	MAIN PCB ASSEMBLY BATTERY 2 Figure 5-3	378083	89536	378083	REF		
BT1	Battery, Ni cad 2	346924	17338	41B004AD15GL	4		
BT2	Battery, Ni cad 2	346924	17338	41B004AD15GL	REF		
BT3	Battery, Ni cad 2	346924	17338	41B004AD15GL	REF		
BT4	Battery, Ni cad 2	346924	17338	41B004AD15GL	REF		
C1	Cap, fxd cer, 0.01uf +80/–20%, 25V	335786	32897	5835-000Y5U 103Z	3		
C2	Cap, fxd cer, 0.01uf +80/–20%, 25V	335786	32897	5835-000Y5U 103Z	REF		
C3	Cap, fxd cer, 0.1uf ± GMV, 10V	368647	71590	UK 10-104	1		
C4	Cap, Ta, 10uf ±20%, 15V	193623	56289	196D106X0015 JA1	3		
C5	Cap, Ta, 22uf ± 20%, 20V 2	357780	56289	196D226X0020 LA3	1		
C6	Cap, fxd cer, 47 pf ± 20%, 100V	369123	56289	C030B102H4705	2		
C7	Cap, Ta, 10uf ±20%, 15V	193623	56289	196D106X0015 JA1	REF		
C8	Cap, fxd cer, 0.001uf ±10%, 500V	357806	71590	CF102	2		
C9	Cap, fxd cer, 47pf ±20%, 100V	369132	56289	C030B102H4705	REF		
C10	Cap, fxd cer, 22pf ±20%, 500V	369157	32897	831-000C0G0220	1		
C11	Cap, var, 22pf	369207	80031	C010KA20E	1		
C12	Cap, Ta, 10uf ±20%, 15V	193623	56289	196D106X0015 JA1	REF		
C13	Cap, fxd cer, 10pf ±10%, 3kV/4.5kV	105536	56289	40C362A1	1		
C14	Cap, Ta, elect, 22pf ±20%, 20V 1	357780	56289	196D226X0020 LA3	1		

MAIN PCB ASSEMBLY LINE

REF DESIG OR ITEM NO.	DESCRIPTION	FLUKE STOCK NO.	MFG FED SPLY CDE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	USE CDE
C15	Cap, elect, 5000pf ±10%, 10V 1	340893	99392	60C10BA553	1		
C16	Cap, elect, 470uf +50/–10%, 25V 1	168153	25403	ET471X025A01	1		
C17	Cap, fxd cer, 0.01uf +80/–20%, 25V	335786	32897	5835-000Y5U 103Z	REF		
CR1	Diode, switching	364224		1N914	3		
CR2	Diode, switching	364224		1N914	REF		
CR3	Diode, zener, uncomp	203547	07910	1N7591A	1		
CR4	Diode, Si, rect 2	343491	*11711	1N4002	6		
CR5	Diode, Si, rect 2	343491	*11711	1N4002	REF		
CR6	Diode, Si, rect 1	343491	*11711	1N4002	REF		
CR7	Diode, Si, rect 1	343491	*11711	1N4002	REF		
CR8	Diode, Si, rect 1	343491	*11711	1N4002	REF		
CR9	Diode, Si, rect 1	343491	*11711	1N4002	REF		
CR10	Diode, Switching	364224		1N914	REF		
F1	Fuse, 1/8 amp, 250V 1	196970	71400	AGC	1		
Q1	Xstr	381780			7		
Q2	Xstr	381780			REF		
Q3	Xstr	381780			REF		
Q4	Xstr	381780			REF		
Q5	Xstr	381780			REF		
Q6	Xstr	381780			REF		
Q7	Xstr	381780			REF		
Q8	Xstr, Si, NPN	218396	04713	2N3904	7		
Q9	Xstr, Si, NPN	218396	04713	2N3904	REF		
Q10	Xstr, Si, NPN	218396	04713	2N3904	REF		
Q11	Xstr, Si, NPN	218396	04713	2N3904	REF		
Q12	Xstr, Si, NPN	218396	04713	2N3904	REF		
Q13	Xstr, Si, NPN	218396	04713	2N3904	REF		
Q14	Xstr,	381798		MPSA13	1		
Q15	Xstr, Si, NPN 1	218396	04713	2N3904	REF		

MAIN PCB ASSEMBLY LINE

REF DESIG OR ITEM NO.	DESCRIPTION	FLUKE STOCK NO.	MFG FED SPLY CDE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	USE CDE
Q16	Xstr, FET ▷1◁	386094		SX3819	1		
R1	Res, comp , 5.6k ±5%, ¼W	148080	01121	CB5625	1		
R2	Res, comp, 470k ±10%, ½W	108290	01121	EB4731	2		
R3	Res, comp, 680Ω ±5%, ¼W	148007	01121	CB6815	1		
R4	Res, comp, 470Ω ±5%, ¼W	108290	01121	EB4731	REF		
R5	Res, comp, 470Ω ±5%, ¼W	147983	01121	CB4715	3		
R6	Res, comp, 2.7k ±5%, ¼W	170720	01121	CB2725	1		
R7	Res, comp, 10k ±5%, ¼W	148106	01121	CB1035	1		
R8	Res, comp, 56Ω± 5%, ¼W	147900	01121	CB5605	1		
R9	Res, comp, 470Ω ±5%, ¼W	147983	01121	CB4715	REF		
R10	Res, comp, 1M ±5%, ¼W	182204	01121	CB1055	1		
R11	Res, comp, 47k ±5%, ¼W	148163	01121	CB4735	1		
R12	Res, comp, 100Ω ±5%, ¼W	147926	01121	CB1015	1		
R13	Res, comp, 100k ±5%, ¼W	148149	01121	CB1045	1		
R14	Res, comp, 470Ω ±5%, ¼W	147983	01121	CB4715	REF		
S1 thru S12							
S13							
T1	Xfmr ▷1◁	387704	89536	387704	1		
T1	Xfmr ▷2◁	1900A-6511	89536	1900A-6511	1		
U1	IC, C-MOS	381848	13327	CM4049AE	3		
U2	IC, TTL, MSI, Decade counter	293159	04713	MC7490P	3		
U3	IC, TTL, BCD to DEC DCOR	293142	04713	MC7442P	1		
U4	IC, C-MOS, Dual type D flip-flop	340117	04713	MC14013CL	3		
U5	IC, C-MOS, NAND Gates	355198	04713	MC14011CP	2		
U6	IC, C-MOS	381848	13327	CM4049AE	REF		
U7	IC, P-MOS	381822		MK5009	1		
U8	IC, TTL, Dual, type D, trig flip-flop	310227	01295	SN7474N	1		
U9	IC, C-MOS, Dual, 4-input, Pos NAND Gate	355206	04713	MC14012CP	1		

MAIN PCB ASSEMBLY LINE

REF DESIG OR ITEM NO.	DESCRIPTION	FLUKE STOCK NO.	MFG FED SPLY CDE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	USE CDE
U10	IC, C-MOS	375147	13327	CM4023AE	2		
U11	IC, C-MOS, NOR Gates	355172	04713	MC14001CL	1		
U12	IC, TTL, MSI, Decade counter	293159	04713	MC7490P	REF		
U13	IC, TTL, BCD to DEC DCDR	340117	04713	MC14013CL	REF		
U14	IC, TTL, BCD to DEC DCDR	340117	04713	MC14013CL	REF		
U15	IC, C-MOS	325147	13327	CM4023AE	REF		
U16	IC, C-MOS	381848	13327	CM4049AE	REF		
U17	IC, TTL, Quad, 2-input POS NAND Gate	293068	04713	MC74H00P	1		
U18	IC, C-MOS, NAND Gates	255198	04713	MC14011CP	REF		
U19	IC, TTL, MSI, Decade counter	293159	04713	MC7490P	REF		
U20	IC, TTL, (Shottky) Dual J-K edge, trig flip-flop	363440	01295	SN745112N	2		
U21	IC, TTL, (Shottky) Dual J-K edge, trig flip-flop	363440	01295	SN745112N	REF		
U22	IC, C-MOS	381830	13327	CM4050AE	1		
U23	IC	385872		7447AN	1		
U24	IC, Digital, MOS	380238		1801A	1		
U25							
U26	IC <1>	381814			1		
Y1	Crystal	385732			1		

NOTE!

Flag note <1> denotes parts used on Main PCB Assembly Line configuration only.

Flag note <2> denotes parts used on Main PCB Assembly Battery configuration only.

* 08466 is vendor code for General Instruments of Canada.

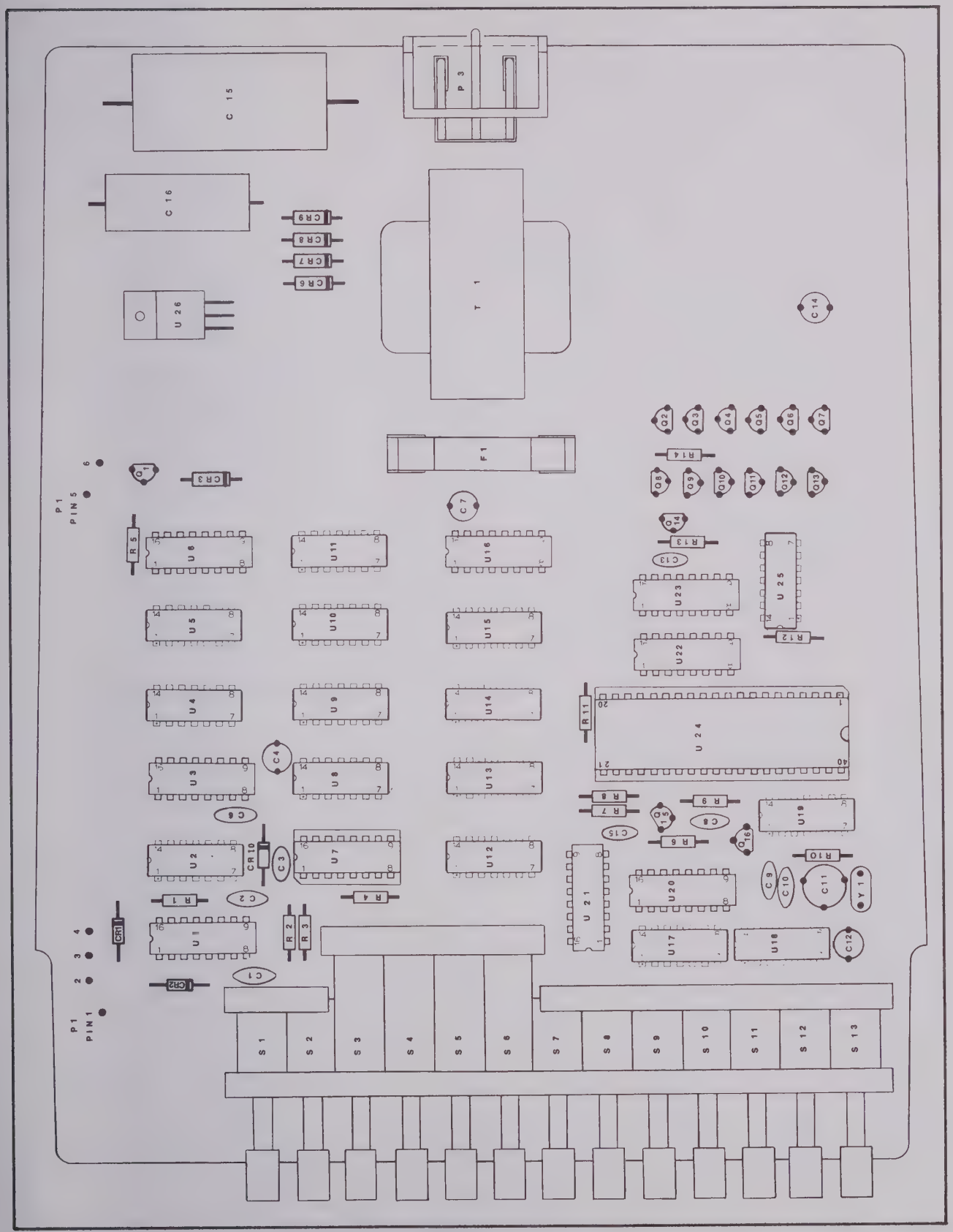


Figure 5-2. MAIN PCB ASSEMBLY – LINE CONFIGURATION

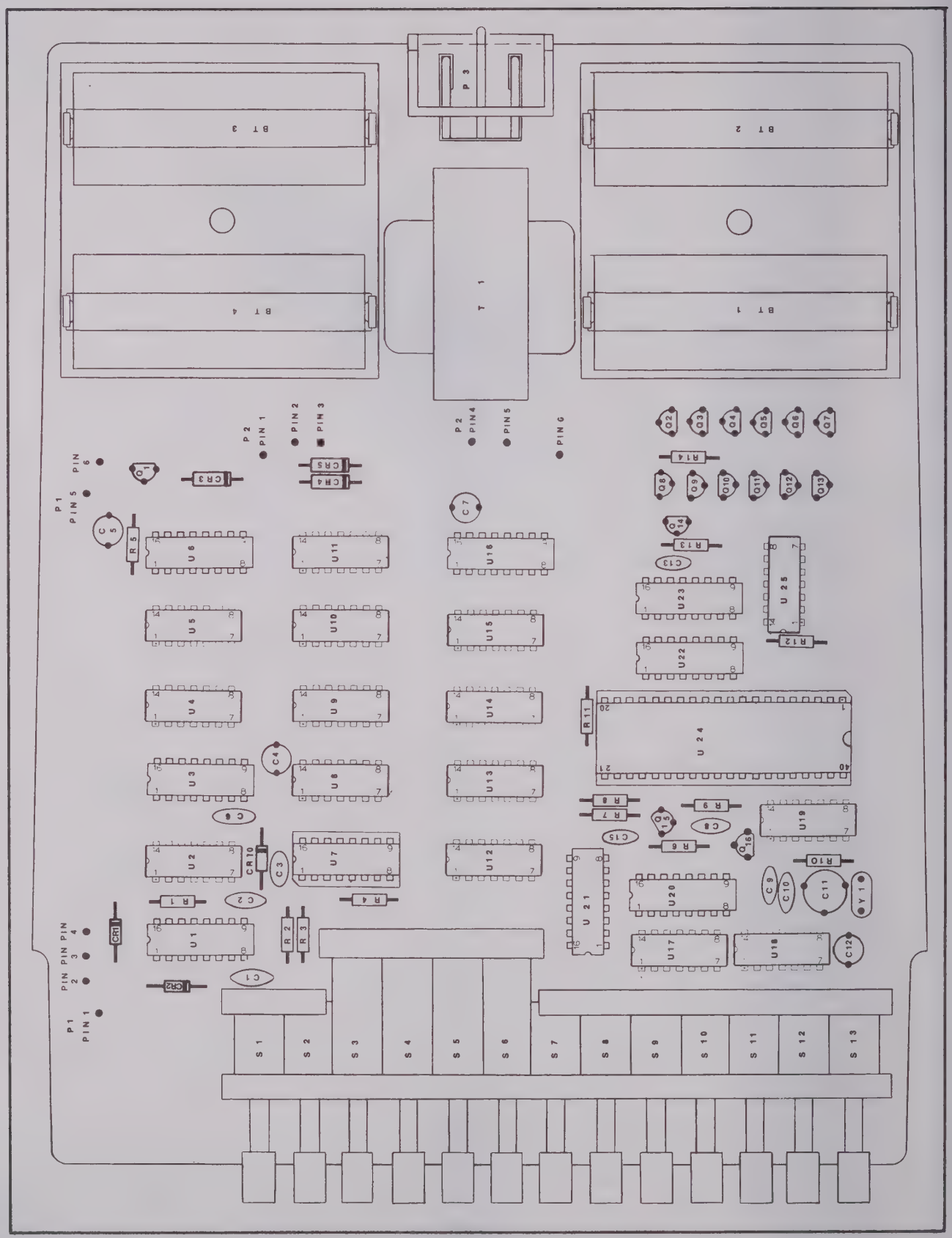


Figure 5-3. MAIN PCB ASSEMBLY – BATTERY (–01 OPTION) CONFIGURATION

INPUT PCB ASSEMBLY

REF DESIG OR ITEM NO.	DESCRIPTION	FLUKE STOCK NO.	MFG FED SPLY CDE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	USE CDE
	INPUT PCB ASSEMBLY **Figure 5-4**	378125	89536	378125	REF		
C1	Cap, fxd cer, 0.1uf +80/–20%, 500V	105684	56289	41C92	1		
C2	Cap, fxd cer, 100pf ±10%, 1kV	105593	71590	DD-101	1		
C3	Cap, fxd cer, 0.01uf +80/–20%, 25V	335786	32897	5835-000Y5U 103Z	4		
C4	Cap, elect, 22uf ±20%, 20V	357780	56289	196D226X0020 LA3	2		
C5	Cap, elect, 22uf ±20%, 20V	357780	56289	196D226X0020 LA3	REF		
C6	Cap, fxd cer, 0.001uf ±10%, 500V	357806	71590	CF-102	1		
C7	Cap, Ta, 10uf ±20%, 15V	193623	56289	196D106X0015 JA1	2		
C8	Cap, fxd cer, 0.01uf +80/–20%, 25V	335786	32897	5835-000Y5U 103Z	REF		
C9	Cap, fxd cer, mini, 2.7pf ±0.25pf	363705	80031	2222-631-09278	1		
C10	Cap, fxd cer, 47pf ±20%, 1000V	369132	56289	C030B102H470 J	1		
C11	Cap, fxd cer, 0.01uf +80/–20%, 25V	335786	32897	5835-000Y5U 103Z	REF		
C12	Cap, Ta, 10uf ±20%, 15V	193632	56289	196D106X0015 JA1	REF		
C13	Cap, fxd cer, 0.01uf +80/–20%, 500V	335786	32897	5835-000YU5 103Z	REF		
CR1	Diode	381806			4		
CR2	Diode	381806			REF		
CR3	Diode	381806			REF		
CR4	Diode	381806			REF		
CR5	Diode	364224			4		
CR6	Diode	364224			REF		
CR7	Diode	364224			REF		
CR8	Diode	364224			REF		
CR9	Diode			1N756A			

INPUT PCB ASSEMBLY

REF DESIG OR ITEM NO.	DESCRIPTION	FLUKE STOCK NO.	MFG FED SPLY CDE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	USE CDE
Q1	Xstr	36911		2N5245	1		
Q2	Xstr, PNP, High speed switch	369629	07263	2N5771	5		
Q3	Xstr, PNP, High speed switch	369629	07263	2N5771	REF		
Q4	Xstr	369645			1		
Q5	Xstr, PNP, High speed switch	369639	07263	2N5771	REF		
Q6	Xstr, PNP, High speed switch	369629	07263	2N5771	REF		
Q7	Xstr, PNP, High speed switch	369629	07263	2N5771	REF		
R1	Res, comp, 120k ±5%, ¼W	193458	01121	CB1245	1		
R2	Res, comp, 180Ω ±5%, ¼W	147942	01121	CB1815	2		
R3	Res, comp, 1M ±5%, ¼W	182204	01121	CB1055	1		
R4	Res, comp, 560Ω ±5%, ¼W	147991	01121	CB5615	9		
R5	Res, comp, 560Ω ±5%, ¼W	147991	01121	CB5615	REF		
R6	Res, comp, 1k ±5%, ¼W	148023	01121	CB1025	2		
R7	Res, comp, 100Ω ±5%, ¼W	147926	01121	CB1015	1		
R8	Res, comp, 10k ±5%, ¼W	148106	01121	CB1035	1		
R9	Res, comp, 3.3k ±5%, ¼W	148056	01121	CB3325	4		
R10	Res, comp, 330Ω ±5%, ¼W	147967	01121	CB3315	1		
R11	Res, comp, 1k ±5%, ¼W	148023	01121	CB1025	REF		
R12	Res, comp, 10Ω ±5%, ¼W	147868	01121	CB1005	1		
R13	Res, comp, 150Ω ±5%, ¼W	147934	01121	CB1515	2		
R14	Res, Trimpot, 10k	385393			1		
R15	Res, comp, 47k ±5%, ¼W	148163	01121	CB4735	1		
R16	Res, comp, 3.3k ±5%, ¼W	148056	01121	CB3325	REF		
R17	Res, comp, 3.3k ±5%, ¼W	148056	01121	CB3325	REF		
R18	Res, comp, 560Ω ±5%, ¼W	147991	01121	CB5615	REF		
R19	Res, comp, 560Ω ±5%, ¼W	147991	01121	CB5615	REF		
R20	Res, comp, 560Ω ±5%, ¼W	147991	01121	CB5615	REF		
R21	Res, comp, 680Ω ±5%, ¼W	148007	01121	CB6815	1		
R22	Res, comp, 560Ω ±5%, ¼W	147991	01121	CB5615	REF		

INPUT PCB ASSEMBLY

REF DESIG OR ITEM NO.	DESCRIPTION	FLUKE STOCK NO.	MFG FED SPLY CDE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	USE CDE
R23	Res, comp, 560Ω ±5%, ¼W	147991	01121	CB5615	REF		
R24	Res, comp, 180Ω ±5%, ¼W	147942	01121	CB1815	REF		
R25	Res, comp, 270Ω ±5%, ¼W	160804	01121	CB2715	1		
R26	Res, comp, 560Ω ±5%, ¼W	147991	01121	CB5615	REF		
R27	Res, comp, 560Ω ±5%, ¼W	147991	01121	CB5615	REF		
R28	Res, comp, 33Ω ±5%, ¼W	175034	01121	CB3305	1		
R29	Res, comp, 3.3k ±5%, ¼W	148056	01121	CB3325	REF		
R30	Res, comp, 150Ω ±5%, ¼W	147934	01121	CB1515	REF		
R31	Res, comp, 220Ω ±5%, ¼W	147959	01121	CB2215	1		
U1	IC, ECL, Tripple line recv	369702	04713	MC10116L	1		

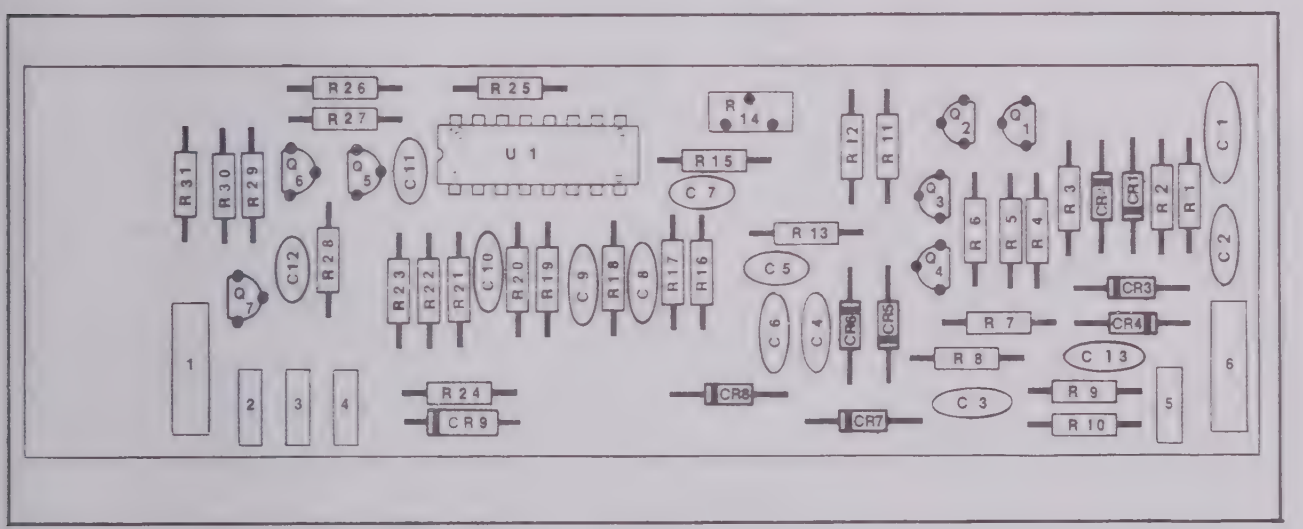


Figure 5-4. INPUT PCB ASSEMBLY

DISPLAY PCB ASSEMBLY

REF DESIG OR ITEM NO.	DESCRIPTION	FLUKE STOCK NO.	MFG FED SPLY CDE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	USE CDE
	DISPLAY PCB ASSEMBLY **Figure 5-5**	378109	89536	378109	REF		
DS201	Diode light emitting	385898		4487	3		
DS202	Diode light emitting	385898		4487	REF		
DS203	Diode light emitting	385898		4487	REF		
U201	Led, Display	380436			6		
U202	Led, Display	380436					
U203	Led, Display	380436					
U204	Led, Display	380436					
U205	Led, Display	380436					
U206	Led, Display	380436					

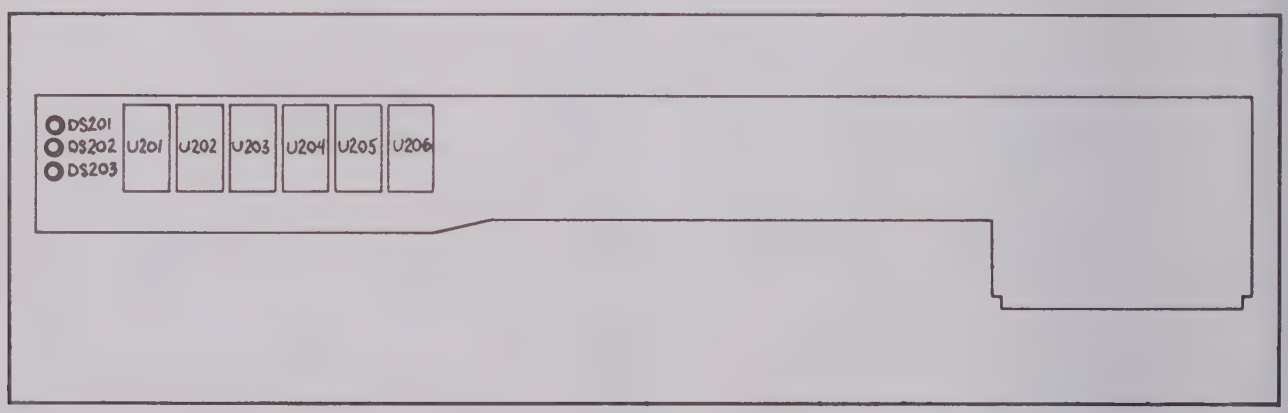


Figure 5-5. DISPLAY PCB ASSEMBLY

INVERTER PCB ASSEMBLY 2

REF DESIG OR ITEM NO.	DESCRIPTION	FLUKE STOCK NO.	MFG FED SPLY CDE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	USE CDE
	INVERTER PCB ASSEMBLY 2 **Figure 5-6**	388447	89536	388447	REF		
C401	Cap, 5uf ± , 200V				1		
C402	Cap, fxd cer, 47pf ± 20%, 100V	369132	56289	C030B102H4705	1		
C403	Cap, Ta, 10uf ±20%, 15V	193623	56289	196D106X0015JA1	1		
C404	Cap, fxd cer, 0.01 uf +80/–20%, 25V	335786	32897	5835-000Y5U103Z	1		
C405	Cap, elect				1		
CR401	Diode, Si, rect	343491	11711	1N4002	2		
CR402	Diode, Si, rect	343491	11711	1N4002	REF		
CR403	Diode, zener	291575	12969	UZ8720	2		
CR404	Diode, zener	291575	12969	UZ8720	REF		
F1	Fuse, ½ amp, 250V	109322	71400	MDL	1		
Q401	Xstr, Si, NPN	369678	01295	T1S98	2		
Q402	Xstr, Si, NPN	369678	01295	T1S98	REF		
R401	Res, comp, 1M ±5%, ¼W	182204	01121	CB1055	1		
R402	Res, comp, 22Ω ±5%, ¼W	147884	01121	CB2205	1		
R403	Res, comp, 330Ω ±5%, ¼W	147967	01121	CB3315	1		
R404	Res, comp, 82Ω ±5%, ¼W	149484	01121	CB8205	1		
T2	Xf mr	372011	89536	372011	1		

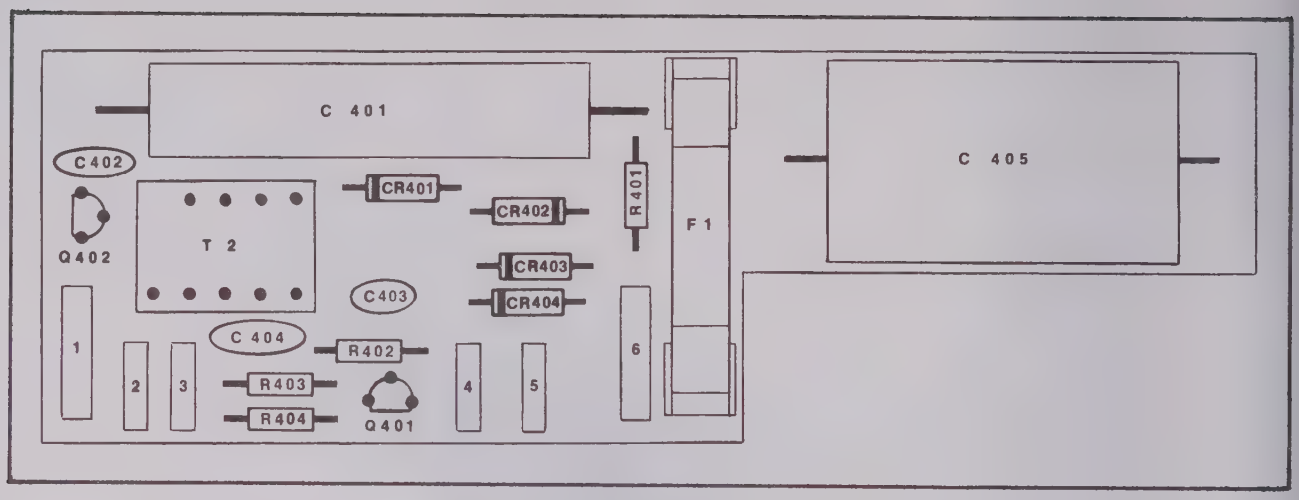


Figure 5-6. INVERTER PCB ASSEMBLY

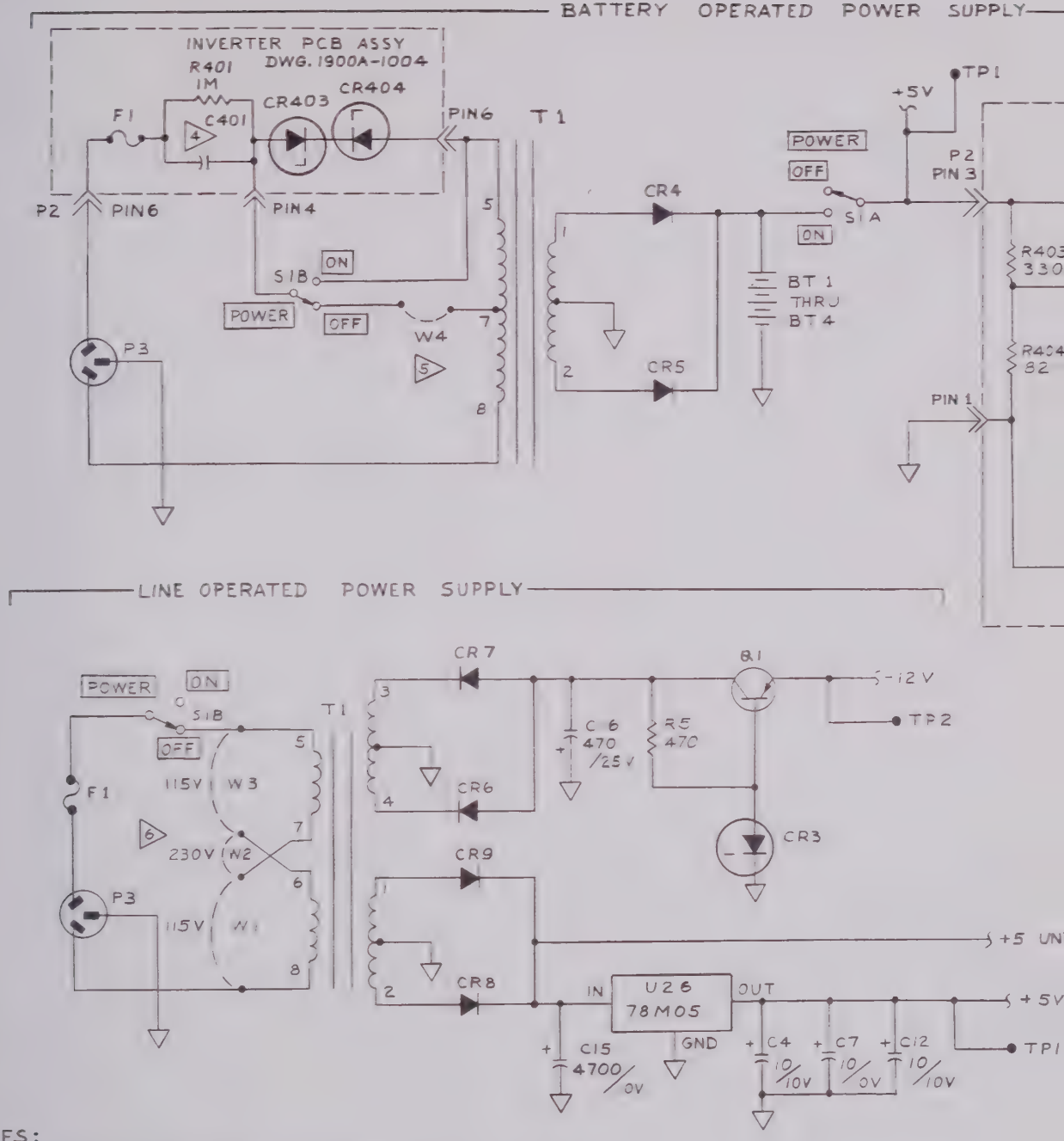
Section 6

Option & Accessory Information

To be supplied in final manual.

Section 7
Schematic Diagrams

FIGURE NO.	NAME	DWG. NO.	PAGE
7-1	Main PCB Assembly	1900A–1001	7-3
7-2	Input PCB Assembly	1900A–1003	7-9
7-3	Display PCB Assembly	1900A–1002	7-11



NOTES:

1. ALL RESISTORS ARE IN OHMS, 1/4 W, 5% C.C. UNLESS OTHERWISE NOTED.
2. ALL CAPACITORS ARE IN MICROFARADS, UNLESS OTHERWISE NOTED.
3. ALL SWITCHES ARE IN RELEASE POSITION.

(4) 6 µf/200VDC FOR 115V/60 Hz BATTERY CONFIGURATION

(5) CONNECT W4 FOR BATTERY CONFIGURATION

(6) IN LINE CONFIGURATION, CONNECT W2 FOR 230V, CONNECT W1 & W3 FOR 115V.

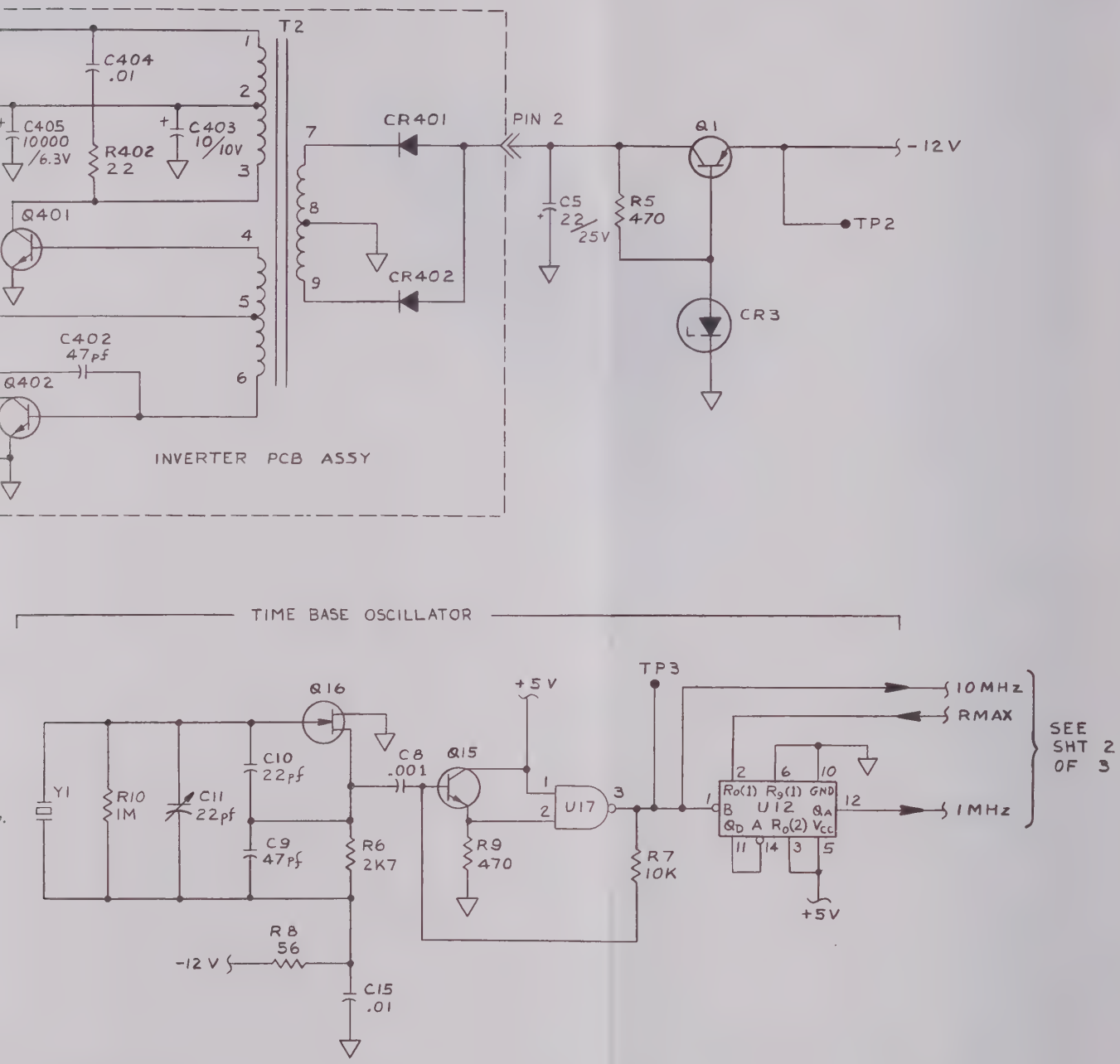
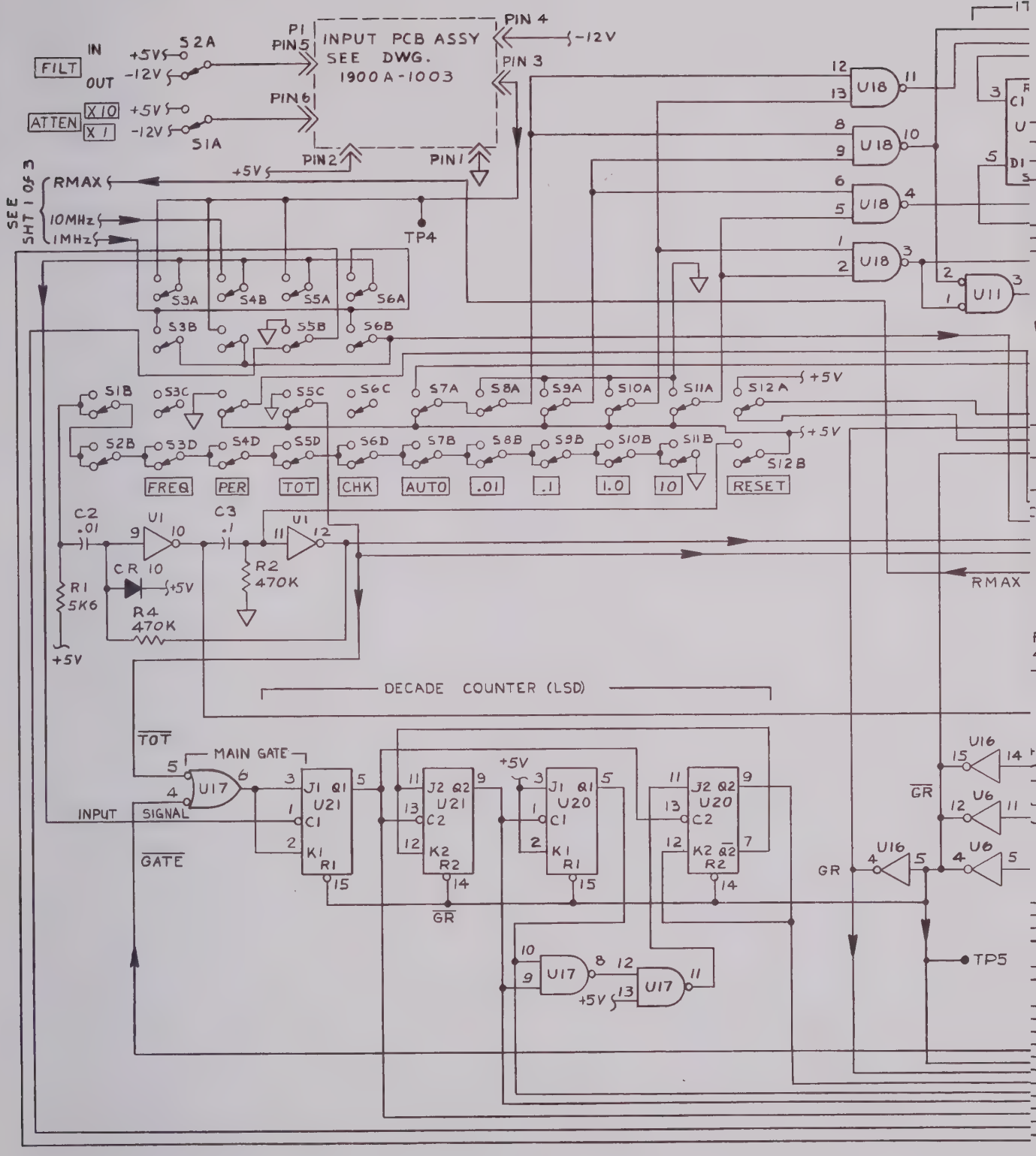


FIGURE 7-1 (1 of 3) MAIN PCB ASSEMBLY (1900A—1001)


FILT
IN
OUT
S2A
+5V
-12V
P1
PIN5
INPUT PCB ASSY
SEE DWG.
1900A-1003
PIN 4
-12V
PIN 3
ATTEN
X10
X1
S1A
PIN6
PIN2
PIN1
SEE SHT 1 OF 3
RMAX
10MHz
1MHz
TP4
S3A
S4B
S5A
S6A
S3B
S5B
S6B
S1B
S3C
S5C
S6C
S7A
S8A
S9A
S10A
S11A
S12A
S2B
S3D
S4D
S5D
S6D
S7B
S8B
S9B
S10B
S11B
S12B
FREQ
PER
TOT
CHK
AUTO
.01
.1
1.0
10
RESET
C2
.01
U1
C3
.1
CR 10
R1
5K6
R4
470K
R2
470K
DECADE COUNTER (LSD)
TOT
MAIN GATE
U17
INPUT SIGNAL
GATE
U21
U20
GR
U18
U11
U16
U6
TP5

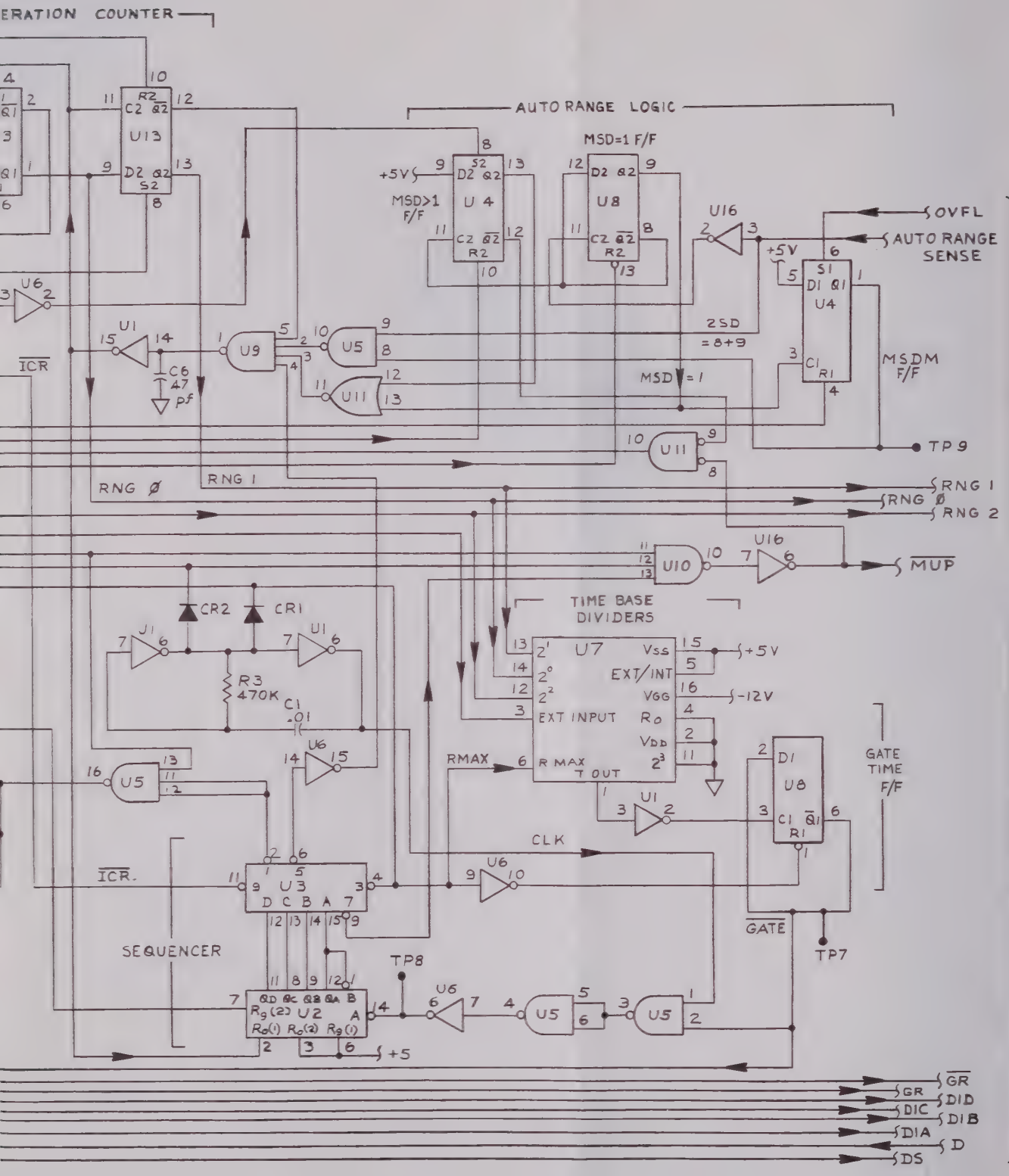
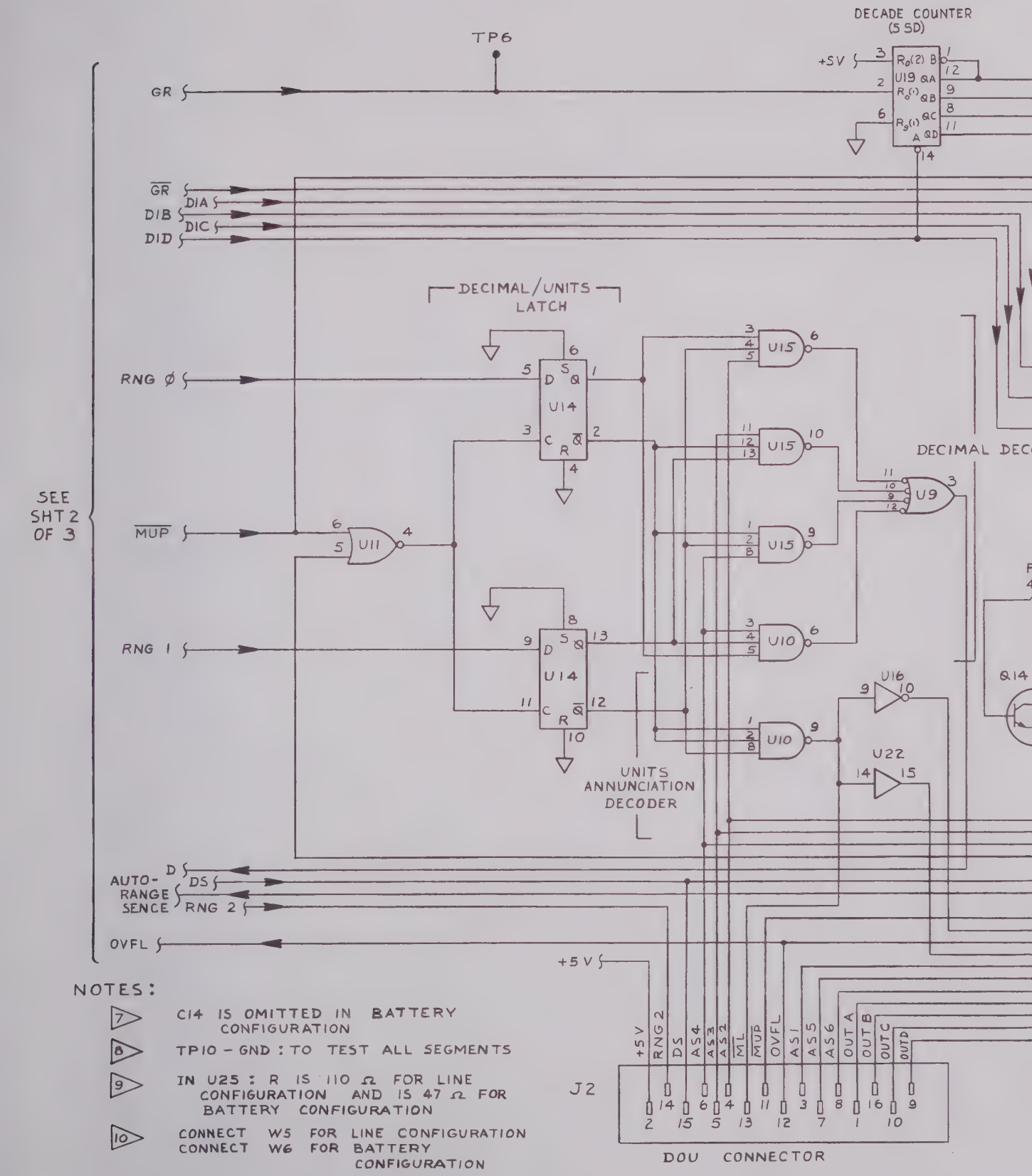


FIGURE 7-1 (2 of 3) MAIN PCB ASSEMBLY
(1900A–1001)



NOTES:

7. C14 IS OMITTED IN BATTERY CONFIGURATION
8. TP10 – GND : TO TEST ALL SEGMENTS
9. IN U25 : R IS 110 Ω FOR LINE CONFIGURATION AND IS 47 Ω FOR BATTERY CONFIGURATION
10. CONNECT W5 FOR LINE CONFIGURATION
    CONNECT W6 FOR BATTERY CONFIGURATION

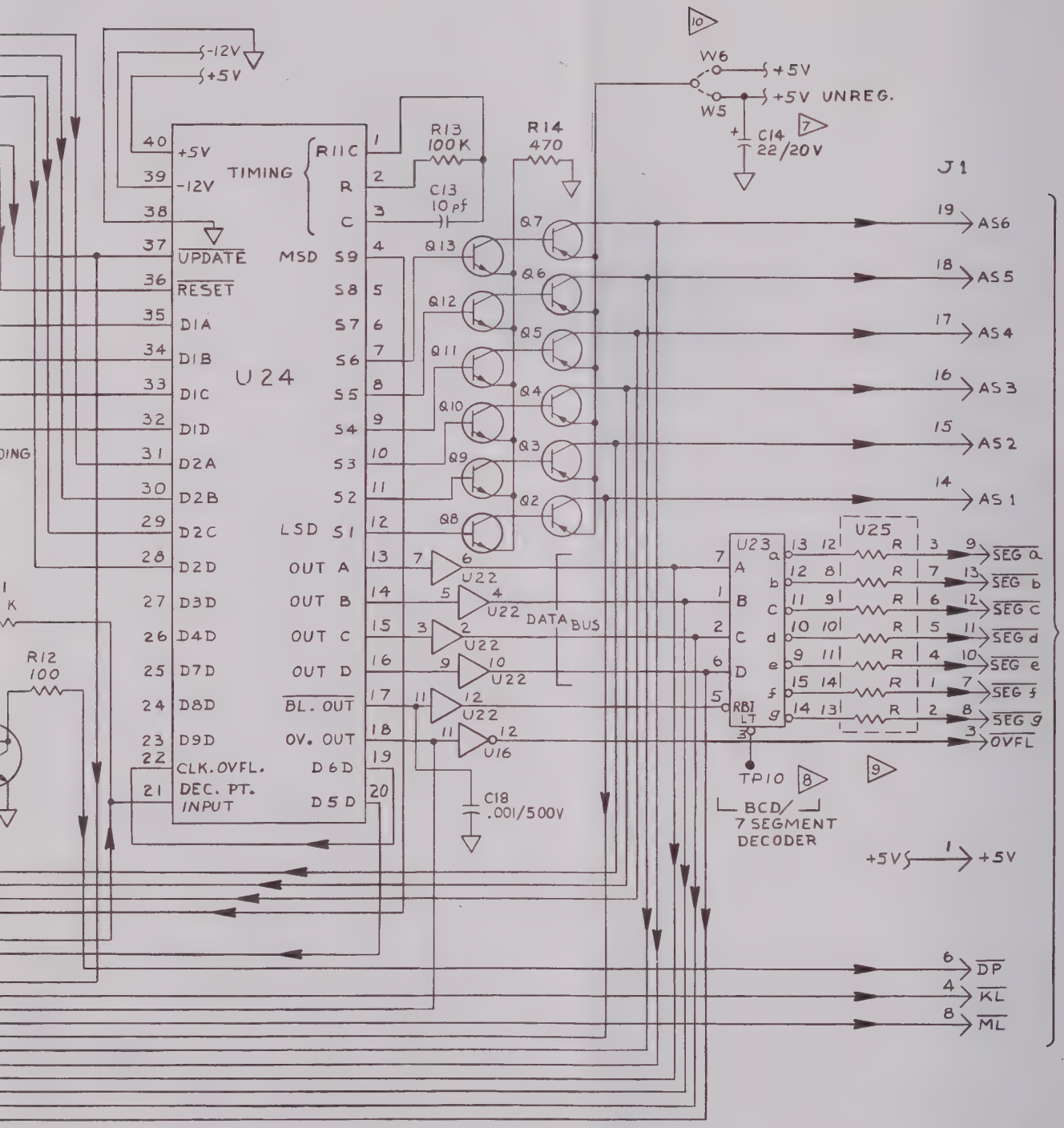
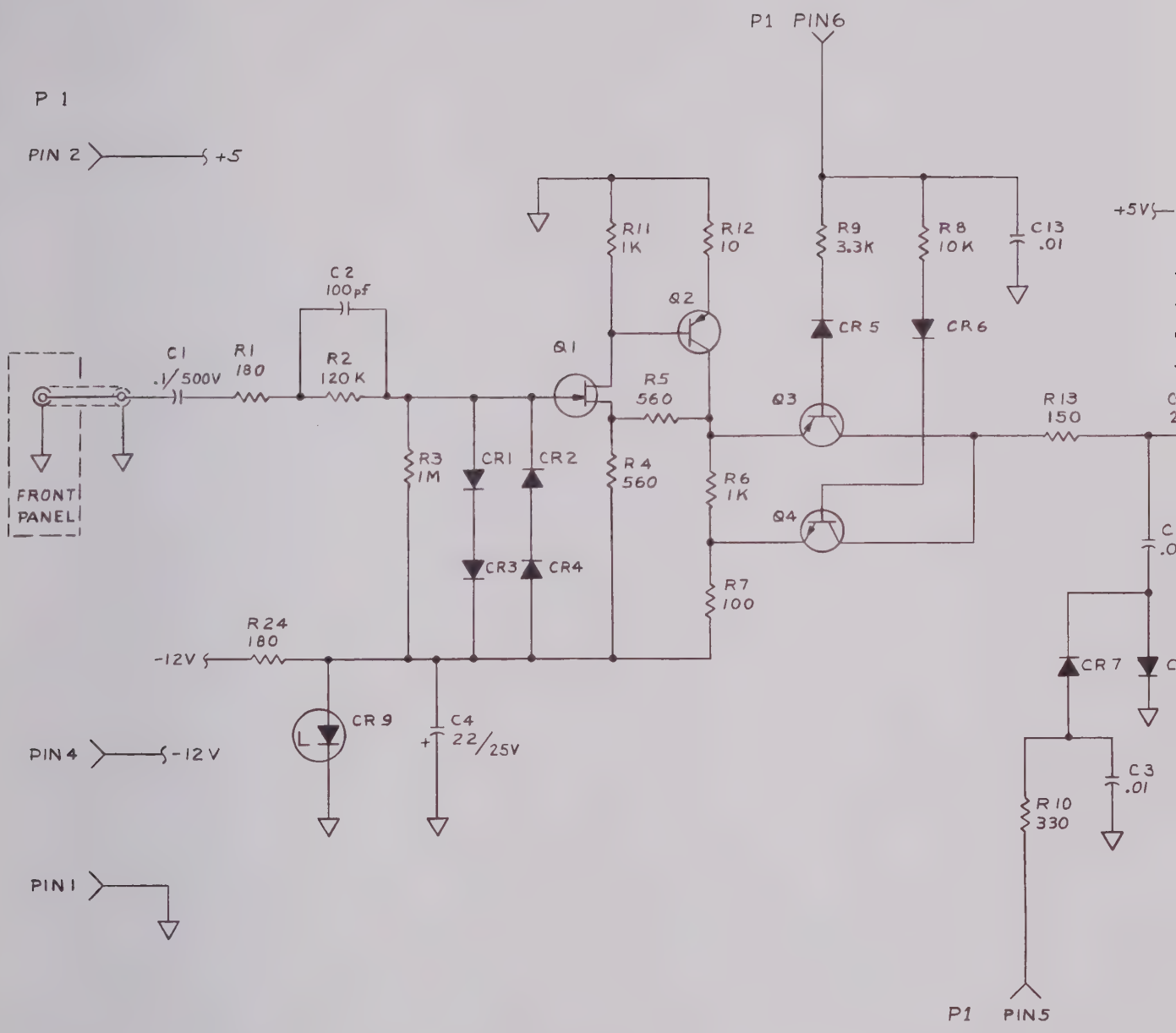
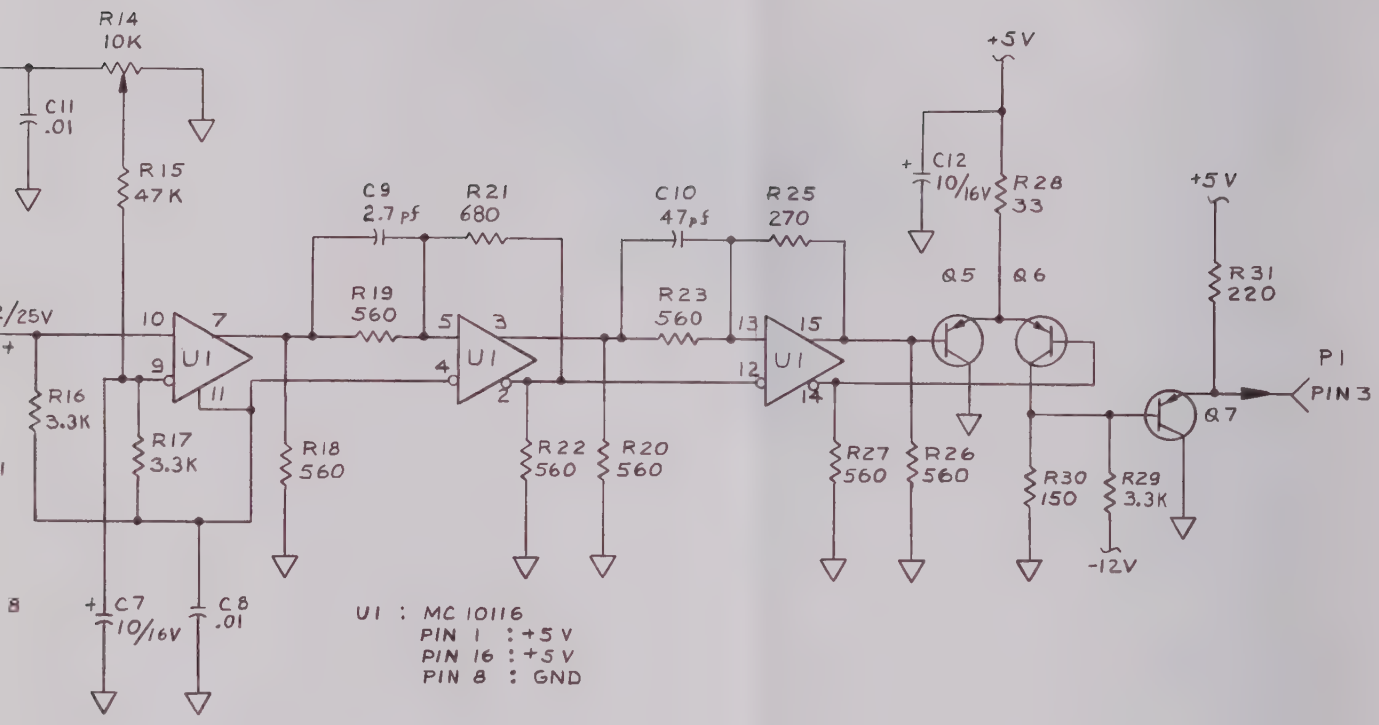


FIGURE 7-1 (3 of 3) MAIN PCB ASSEMBLY (1900A–1001)

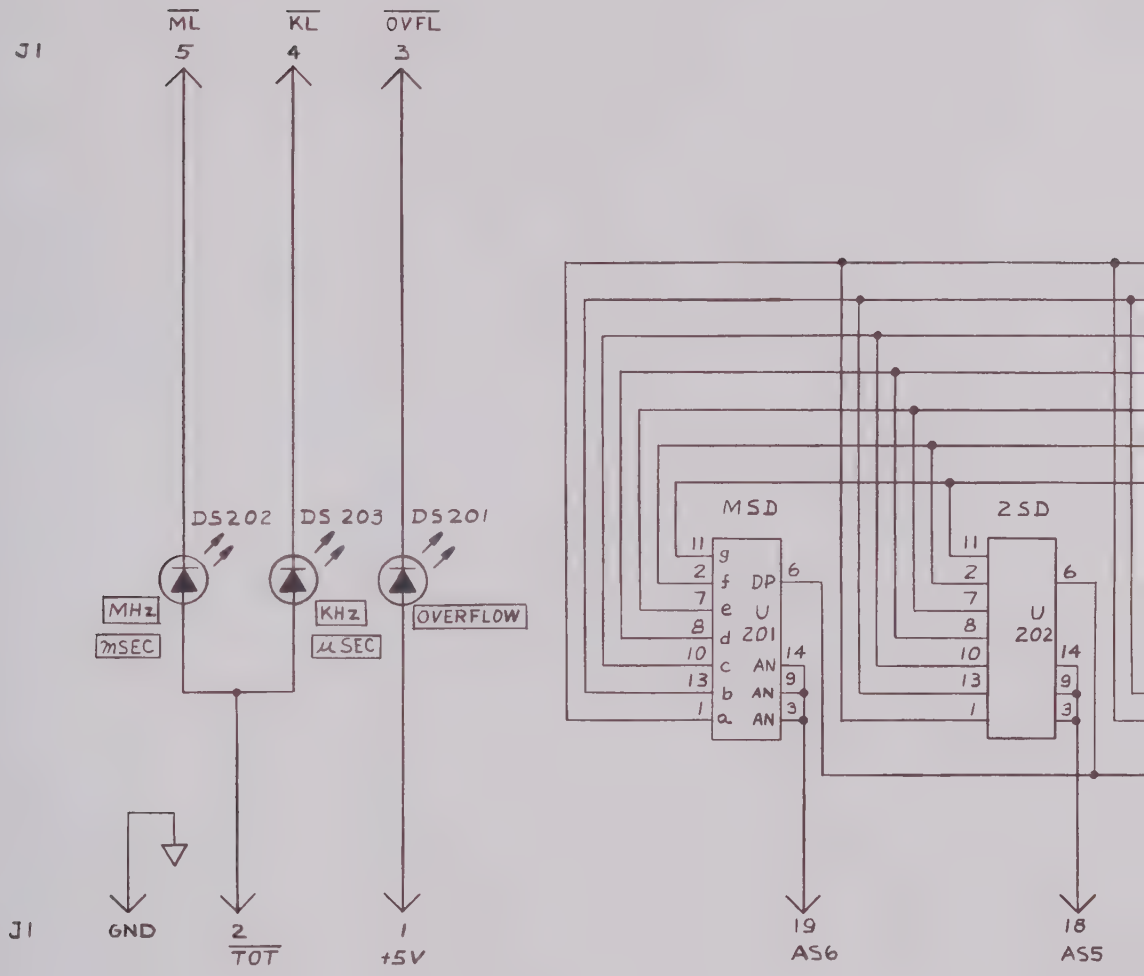

P1 PIN6
P 1
PIN 2
+5
+5V
R11
1K
R12
10
R9
3.3K
R8
10K
C13
.01
C2
100pf
Q2
CR5
CR6
C1
.1/500V
R1
180
R2
120K
Q1
R5
560
Q3
R13
150
FRONT
PANEL
R3
1M
CR1
CR2
R4
560
R6
1K
Q4
CR3
CR4
R7
100
R24
180
-12V
CR7
CR9
C4
22/25V
PIN4
-12V
C3
.01
R10
330
PIN1
P1 PIN5



NOTES:

1. ALL RESISTORS ARE IN OHMS, 1/4 W., 5 % C.C. UNLESS OTHERWISE NOTED.
2. ALL CAPACITORS ARE IN MICROFARADS, UNLESS OTHERWISE NOTED.

FIGURE 7-2 INPUT PCB ASSEMBLY (1900A—1003)



NOTE :

1. U201 THRU U206 CONTAIN A SEVEN SEGMENT LED DISPLAY

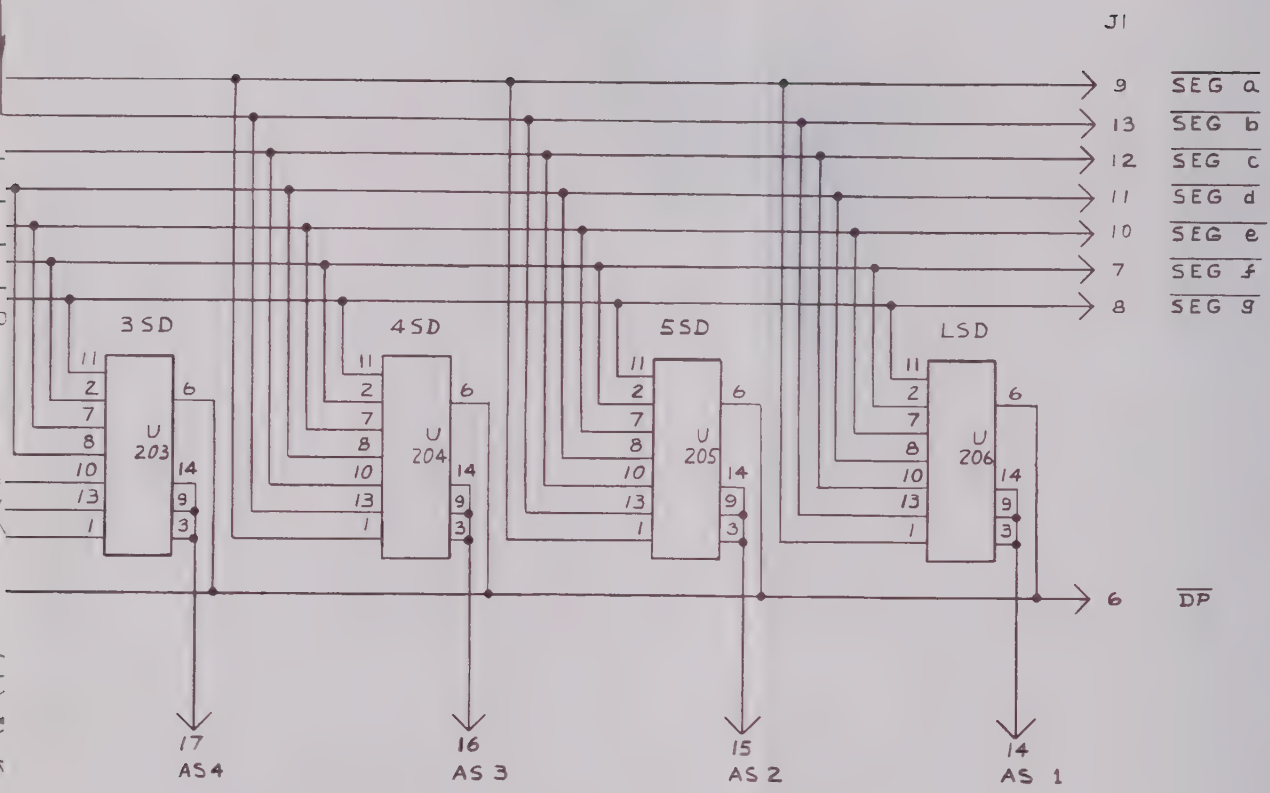


FIGURE 7-3 DISPLAY PCB ASSEMBLY (1900A–1002)

Appendix A

Federal Supply Code for Manufacturers

A-1. CODE TO NAME

A-2. The following five digit code numbers are listed in numerical sequence along with the manufacturer's name and address to which the code has been assigned. The Federal Supply Code has been taken from Cataloging Handbook H 4-2, Code to Name.

00213 Sage Electronics Corp.
Rochester, New York

00327 Welwyn International, Inc.
Westlake, Ohio

00656 Aerovox Corp.
New Bedford, Massachusetts

00686 Film Capacitors
Passaic, New Jersey

00779 AMP Inc.
Harrisberg, Pennsylvania

01121 Allen-Bradley Co.
Milwaukee, Wisconsin

01281 TRW Semiconductors
Lawndale, California

01295 Texas Instruments, Inc.
Semiconductor Components Div.
Dallas, Texas

01686 RCL Electronics Inc.
Manchester, New Hampshire

01730 Deleted

01884 Dearborn Electronics Inc.
Orlando, Florida

02114 Ferroxcube Corp.
Saugerties, New York

02606 Replaced by 15801

02660 Amphenol-Borg Elect. Corp.
Broadview, Illinois

02799 Arco Capacitors, Inc.
Torrence, California

03508 General Electric Co.
Semiconductor Products
Syracuse, New York

03614 Replaced by 71400

03651 Replaced by 44655

03797 Eldema Corp.
Compton, California

03877 Transitron Electronic Corp.
Wakefield, Massachusetts

03888 Pyrofilm Resistor Co., Inc.
Cedar Knolls, New Jersey

03911 Clairex Corp.
New York, New York

03980 Muirhead Instruments, Inc.
Mountainside, New Jersey

04009 Arrow Hart and Hegemen
Electronic Company
Hartford, Connecticut

04062 Replaced by 72136

04202 Replaced by 81312

04217 Essex Wire Corp.
Wire & Cable Div.
Anaheim, California

04221 Aemco, Div. of
Midtex Inc.
Mankato, Minnesota

04222 Aerovox Corp. (H-Q)
Myrtle Beach, South Carolina

04645 Replaced by 75376

04713 Motorola Semiconductor Products Inc.
Phoenix, Arizona

05082 Replaced by 94154

05236 Jonathan Mfg. Co.
Fullerton, California

05277 Westinghouse Electric Corp.
Semiconductor Dept.
Youngwood, Pennsylvania

05278 Replaced by 43543

05397 Union Carbide Corp.
Electronics Div.
Cleveland, Ohio

05279 Southwest Machine & Plastic Co.
Los Angeles, California

05397 Union Carbide Corp.
Electronics Div.
New York, New York

05571 Sprague Electric Co.
Pacific Div.
Los Angeles, California

05574 Viking Industries
Chatsworth, California

05704 Alac, Inc.
Glendale, California

05820 Wakefield Engineering Ind.
Wakefield, Massachusetts

06001 General Electric Company
Capacitor Department
Irmo, South Carolina

06136 Replaced by 63743

06473 Amphenol Space & Missile Sys.
Chatsworth, California

06555 Beede Electrical Instrument Co.
Penacook, New Hampshire

06739 Electron Corp.
Littletown, Colorado

06743 Clevite Corp.
Cleveland, Ohio

06751 Semcor Div., Components, Inc.
Phoenix, Arizona

06860 Gould National Batteries Inc.
City of Industry, California

06980 Varian-Eimac
San Carlos, California

07115 Replaced by 14674

07138 Westinghouse Electric
Corp., Electronic
Tube Division
Elmira, New York

07256 Silicon Transistor Corp.
Garden City, New York

07263 Fairchild Semiconductor
Div. of Fairchild Camera
& Instrument Corp.
Mountain View, California

07344 Bircher Co., Inc.
Rochester, New York

07792 Lerma Engineering Corp.
Northampton, Massachusetts

07910 Teledyne Corp.
(Continental Device)
Hawthorne, California

08225 Industro Transistor Corp.
Long Island City, New York

08530 Reliance Mica Corp.
Brooklyn, New York

08792 Discontinued

08806 General Electric Co.
Miniature Lamp Dept.
Cleveland, Ohio

08863 Nylomatic Corp.
Norrisville, Pennsylvania

08988 Skottie Electronics Inc.
Archbald, Pennsylvania

09353 C and K Components
Watertown, Massachusetts

09423 Scientific Components, Inc.
Santa Barbara, California

09922 Burndy Corp.
Norwalk, Connecticut

11236 CTS of Berne
Berne, Indiana

11237 Chicago Telephone of
Calif., Inc. (CTC)
Paso Robles, California

11358 Discontinued

11403 Best Products Co.
Chicago, Illinois

11503	Keystone Mfg. Div. of Avis Industrial Corp. Warren, Michigan
11726	Qualidyne Corp. Santa Clara, California
12014	Chicago Rivet & Machine Co. Bellwood, Illinois
12040	National Semiconductor Corp. Danburry, Connecticut
12060	Diodes, Inc. Chatsworth, California
12136	Philadelphia Handle Co. Camden, New Jersey
12323	Presin Co., Inc. Shelton, Connecticut
12327	Freeway Washer & Stamping Co. Cleveland, Ohio
12400	Replaced by 75042
12617	Hamlin Inc. Lake Mills, Wisconsin
12697	Clarostat Mfg. Co. Dover, New Hampshire
12749	James Electronics Chicago, Illinois
12856	Micrometals Sierra Madre, California
12954	Dickson Electronics Corp. Scottsdale, Arizona
12969	Unitrode Corp. Watertown, Massachusetts
13103	Thermalloy Co. Dallas, Texas
13511	Amphenol Corp. Los Gatos, California
13606	Sprague Electric Co. Transistor Div. Concord, New Hampshire
13839	Replaced by 23732
14099	Semtech Corp. Newbury Park, California
14193	California Resistor Corp. Santa Monica, California
14298	American Components, Inc. Conshohocken, Pennsylvania
14655	Cornell-Dubilier Electronics Newark, New Jersey
14674	Discontinued, see 16299
14752	Electro Cube Inc. San Gabriel, California
14869	Replaced by 96853
15636	Elec-Trol Inc. Northridge, California
15801	Fenwal Electronics Inc. Framingham, Massachusetts
15818	Amelco Semiconductor Div. of Teledyne Inc. Mountain View, California
15849	USECO, Inc. Mt. Vernon, New York
15898	International Business Machines (IBM) Essex Junction, Vermont
15909	Replaced by 17870
16299	Corning Glass Raleigh, North Carolina
16332	Replaced by 28478
16473	Cambridge Scientific Ind. Inc. Cambridge, Maryland
16742	Paramount Plastics Downey, California
16758	Delco Radio Div. of General Motors Kokomo, Indiana
17001	ITT Cannon Santa Ana, California
17069	Circuit Structures Lab. Upland, California
17856	Siliconix, Inc. Sunnyvale, California
17870	Daven-Div of Thomas A. Edison Ind. – McGraw - Edison Co. Manchester, New Hampshire
18083	Deleted
18178	Vactec Inc. Maryland Heights, Missouri
18612	Vishay Intertechnology Inc. Malvern, Pennsylvania
18736	Voltronics Corp. Hanover, New Jersey
19429	Discontinued, use 89536
19451	Perine Machinery & Supply Co. Seattle, Washington
19701	Electra Mfg. Co. Independence, Kansas
20584	Enochs Mfg. Co. Indianapolis, Indiana
20891	Self-Organizing Systems, Inc. Dallas, Texas
22767	ITT Semiconductors Div. of ITT Palo Alto, California
23050	Product Comp. Corp. Mount Vernon, New York
23732	Tracor Rockville, Maryland
23880	Stanford Applied Engrng. Santa Clara, California
23936	Pamotor Div., Wm. J. Purdy Co. Burlingame, California
24248	Southco Div. of South Chester Corp. Lester, Pennsylvania
24655	General Radio Co. West Concord, Massachusetts
24759	Lenox-Fugle Electronics Plainfield, New Jersey
25403	Amperex Electronic Corp. Semiconductor & Receiving Tube Division Slatersville, Rhode Island
27014	National Semiconductor Corp. Santa Clara, California
27264	Molex Products Downers Grove, Illinois
28425	Bohannon Industries Fort Worth, Texas
28478	Deltrol Controls, Corp. Milwaukee, Wisconsin
28480	Hewlett Packard Co. Palo Alto, California
28520	Heyman Mfg. Co. Kenilworth, New Jersey
29083	Monsanto, Co., Inc. Santa Clara, California
30323	Illinois Tool Works, Inc. Chicago, Illinois
32539	Mura Corp. Great Neck, New York
32767	Griffith Plastic Products Co. Burlingame, California
32879	Advanced Mechanical Components Northridge, California
32897	Erie Technological Products, Incorporated Frequency Control Div. Carlisle, Pennsylvania
33173	General Electric Co., Tube Dept. Owensboro, Kentucky
34333	Silicon General Westminster, California
34335	Advanced Micro Devices, Sunnyvale, California
37942	Mallory, P. R. & Co., Inc. Indianapolis, Indiana
42498	National Company Melrose, Massachusetts
43543	Nytronics Inc. Transformer Co. Div. Alpha, New Jersey
44655	Ohmite Mfg. Co. Skokie, Illinois
49671	Radio Corp. of America New York, New York
49956	Raytheon Company Lexington, Maine
53021	Sanamo Electric Co. Springfield, Illinois
55026	Simpson Electric Company Chicago, Illinois
56289	Sprague Electric Co. North Adam s, Massachusetts
58474	Superior Electric Co. Bristol, Connecticut
60399	Torrington Mfg. Co. Torrington, Connecticut
62460	Deleted
63743	Ward Leonard Electric Co. Mount Vernon, New York
64834	West Mfg. Co. San Francisco, California
65092	Weston Instruments Inc. Newark, New Jersey
66150	Winslow Tele-Tronics Inc. Asbury Park, New Jersey
70563	Amperite Company Union City, New Jersey
70903	Belden Mfg. Co. Chicago, Illinois
71002	Birnbach Radio Co., Inc. New York, New York
71236	"ELMENCO" Willimantic, Connecticut
71400	Bussmann Mfg. Div. of McGraw - Edison Co. Saint Louis, Missouri
71450	CTS Corp. Elkhart, Indiana
71468	ITT Cannon Electric Inc. Los Angeles, California
71482	Clare, C. P. & Co. Chicago, Illinois
71590	Centralab Div. of Globe Union Inc. Milwaukee, Wisconsin
71707	Coto Coil Co., Inc. Providence, Rhode Island
71744	Chicago Miniature Lamp Works Chicago, Illinois
71785	Cinch Mfg. Co. & Howard B. Jones Div. Chicago, Illinois
72005	Driver, Wilber B., Co. Newark, New Jersey
72092	Replaced by 06980
72136	Electro Motive Mfg. Co. Willimantic, Connecticut
72259	Nytronics Inc. Berkeley Heights, New Jersey
72354	Deleted
72619	Dialight Corp. Brooklyn, New York
72653	G. C. Electronics Rockford, Illinois
72665	Replaced by 90303
72794	Dzus Fastener Co., Inc. West Islip, New York
72928	Gudeman Co. (Gulton Industries) Chicago, Illinois
72982	Erie Tech. Products Inc. Erie, Pennsylvania
73138	Beckman Instruments Inc. Helipot Division Fullerton, California
73293	Hughes Aircraft Co. Electron Dynamics Div. Torrence, California
73445	Amperex Electronic Corp. Hicksville, New York
73559	Carling Electric Inc. Hartford, Connecticut
73586	Circle F Industries Trenton, New Jersey
73734	Federal Screw Products, Inc. Chicago, Illinois

73743	Fischer Special Mfg. Co. Cincinnati, Ohio
73899	JFD Electronics Co. Brooklyn, New York
73949	Guardian Electric Mfg. Co Chicago, Illinois
74199	Quam Nichols Co. Chicago, Illinois
74217	Radio Switch Corp. Marlboro, New Jersey
74276	Signalite Inc. Neptune, New Jersey
74306	Piezo Crystal Co. Carlisle, Pennsylvania
74542	Hoyt Elect. Instr. Works Penacook, New Hampshire
74970	Johnson, E. F., Co. Waseca, Minnesota
75042	IRC Inc. (Div. of TRW) Philadelphia, Pennsylvania
75376	Kurz-Kasch, Inc. Dayton, Ohio
75382	Kulka Electric Corp. Mount Vernon, New York
75915	Littlefuse Inc. Des Plaines, Illinois
76854	Oak Mfg. Co. Crystal Lake, Illinois
77342	Potter & Brumfield Div. of Amer. Machine & Foundry Princeton, Indiana
77969	Rubbercraft Corp. of Calif. LTD. Torrance, California
78189	Shakeproof Div. of Illinois Tool Works Elgin, Illinois
78277	Sigma Instruments, Inc. South Braintree, Massachusetts
78488	Stackpole Carbon Co. Saint Marys, Pennsylvania
78553	Tinnerman Products Cleveland, Ohio
79136	Waldes Kohinoor Inc. Long Island City, New York
79497	Western Rubber Company Goshen, Indiana
79963	Zierick Mfg. Corp. New Rochelle, New York
80031	Mepco Div. of Sessions Clock Co. Morristown, New Jersey
80145	API Instruments Co. Chesterland, Ohio
80183	Sprague Products North Adams, Massachusetts
80294	Bourns Inc. Riverside, California
80583	Hammarlund Co., Inc. Mars Hill, North Carolina
80640	Stevens, Arnold Inc. Boston, Massachusetts
81073	Grayhill Inc. La Grange, Illinois
81590	Korry Mfg. Co. Seattle, Washington
81312	Winchester Electronics Div. of Litton Industries Oakville, Connecticut
81439	Therm-O-Disc Inc. Mansfield, Ohio
81483	International Rectifier Corp. Los Angeles, California
81741	Chicago Lock Corp. Chicago, Illinois
82305	Palmer Electronics South Gate, California 90280
82389	Switchcraft Inc. Chicago, Illinois
82415	Price Electric Corp. Frederick, Maryland
82872	Roanwell Corp. New York, New York
82877	Rotron Mfg. Co., Inc. Woodstock, New York
82879	ITT Wire & Cable Div. Pawtucket, Rhode Island
83003	Varo Inc. Garland, Texas
83298	Bendix Corp. Electric Power Division Eatontown, New Jersey
83330	Smith, Herman H., Inc. Brooklyn, New York
83478	Rubbercraft Corp. of America New Haven, Connecticut
83594	Burroughs Corp. Electronic Components Div. Plainfield, New Jersey
83740	Union Carbide Corp. Consumer Products Div. New York, New York
84171	Arco Electronics, Inc. Great Neck, New York
84411	TRW Ogallala, Nebraska
86577	Precision Metal Products Stoneham, Massachusetts
86684	Radio Corp. of America Electronic Components & Devices Harrison, New Jersey
86689	Deleted
87034	Marco-Oak Inc. Anaheim, California
88245	Litton Products Inc. Van Nuys, California
88419	Use 14655
88690	Replaced by 04217
89536	Fluke, John Mfg. Co., Inc. Seattle, Washington
89730	Replaced by 08806
90201	Mallory Capacitor Co. Indianapolis, Indiana
90215	Best Stamp & Mfg. Co Kansas City, Missouri
90211	Square D Co. Chicago, Illinois
90303	Mallory Battery Co. Tarrytown, New York
91293	Johanson Mfg. Co. Boonton, New Jersey
91407	Replaced by 58474
91502	Associated Machine Santa Clara, California
91506	Augat Attleboro, Mass.
91637	Dale Electronics Inc. Columbus, Nebraska
91662	Elco Corp. Willow Grove, Pennsylvania
91737	Gremar Mfg Co., Inc. (ITT) Woburn, Massachusetts
91802	Industrial Devices, Inc. Edgewater, New Jersey
91836	King's Electronics Tuckahoe, New York
91929	Honeywell Inc. Micro Switch Div. Freeport, Illinois
91934	Miller Electric Co., Inc. Pawtucket, Rhode Island
93332	Sylvania Electric Products Semiconductor Products Div Woburn, Massachusetts
94145	Replaced by 49956
94154	Tung-Sol Div. of Wagner Electric Corp. Newark, New Jersey
95146	Alco Electronics Products Inc. Lawrence, Massachusetts
95263	Leecraft Mfg. Co. Long Island City, New York
95264	Replaced by 98278
95275	Vitramon Inc. Bridgeport, Connecticut
95303	Radio Corp. of America Solid State & Receiving Tube Div. Cincinnati, Ohio
95354	Methode Mfg. Corp. Rolling Meadows, Illinois
95712	Dage Electric Co., Inc. Franklin, Indiana
95987	Weckesser Co. Inc. Chicago, Illinois
96733	San Fernando Electric Mfg. Co. San Fernando, California
96853	Rustrak Instrument Co. Manchester, New Hampshire
96881	Thomson Industries, Inc. Manhasset, New York
97540	Master Mobile Mounts Div. of Whitehall Electronics Corp. Los Angeles, California
97913	Industrial Electronic Hdware Corp. New York, New York
97945	White, S. S. Co. Plastics Div. New York, New York
97966	Replaced by 11358
98094	Replaced by 49956
98159	Rubber-Teck, Inc. Gardena, California
98278	Microdot Inc. Pasadena, California
98291	Sealectro Corp. Conhex Div. Mamaroneck, New York
98388	Accurate Rubber & Plastics Culver City, California
98743	Replaced by 12749
98925	Deleted
99120	Plastic Capacitors, Inc. Chicago, Illinois
99217	Southern Electronics Corp. Burbank, California
99392	STM Oakland, California
99515	Marshall Industries Capacitor Div. Monrovia, California
99779	Barnes Corp. Lansdowne, Pennsylvania Toyo Electronics (R-Ohm Corp.) Irvine, California 92664 National Connector Minneapolis, Minn. 55436

Appendix B
List of Abbreviations

alternating current	ac
ampere	A
assembly	assy
binary coded decimal	bcd
bel	B
capacitor	cap
centimeter	cm
ceramic	cer
clockwise	cw
common-mode rejection ratio	cmrr
composition	comp
counterclockwise	ccw
decibel	dB
degree Celsius	°C
degree Fahrenheit	°F
digital voltmeter	dvm
direct current	dc
electrolytic	elect
external	ext
farad	F
field effect transistor	FET
germanium	Ge
giga (10^9)	G
gigahertz	GHz
ground	gnd
guard	gd
henry	H
hertz	Hz
high frequency	hg
hour	h
inch	in
integrated circuit	IC
intermediate frequency	if
internal	intl
kilo (10^3)	k
kilohertz	kHz
kilohm	kΩ
kilovolt	kV
low frequency	lf
maximum	max
mega (10^6)	M
megahertz	MHz
megohm	MΩ
meter	m
micro (10^{-6})	μ
microsecond	μs
milli (10^{-3})	m
milliamperes	mA
millimeter	mm
millisecond	ms
millivolt	mV
minimum	min
nano (10^{-9})	n
nanosecond	ns
negative	neg
ohm	Ω
oscilloscope	scope
parts per million	ppm
peak-to-peak	p-p
pico (10^{-12})	p
picofarad	pF
plus or minus	±
positive	pos
plastic	plstc
printed circuit board	pcb
radio frequency	rf
root mean square	rms
second (time)	s
serial number	SN
silicon	Si
tantalum	Ta
temperature coefficient	TC
tera (10^{12})	T
transformer	xfmr
transistor	xstr
ultra high frequency	uhf
variable	var
very high frequency	vhf
very low frequency	vlf
volt	V
voltage controlled oscillator	vco
watt	W
wirewound	ww

Appendix C

Sales Representatives

ALABAMA

HUNTSVILLE
BCS Associates, Inc.
3322 S. Memorial Parkway
P.O. Box 1273
Tel. (205) 881-6220
Zip 35801

ALASKA

SEATTLE
Showalter-Judd, Inc.
5616 4th Ave. South
Tel. (206) 762-2310
Zip 98108

ARIZONA

PHOENIX
Barnhill Associates
7329 E. Stetson Dr.
Tel. (602) 947-7841
Scottsdale, AZ 85251

CALIFORNIA

LOS ANGELES
Instrument Specialists, Inc.
1109 S. Central Ave.
Glendale, California 91204
Tel. (213) 245-9404

SANTA CLARA
Instrument Specialists, Inc.
2359 De La Cruz Blvd.
Tel. (408) 244-1505
Zip 95050

SAN DIEGO
Instrument Specialists, Inc.
4805 Mercury St., Ste. 1
Tel. (714) 565-2555
Zip 92111

COLORADO

DENVER
Barnhill Associates
1170 S. Sheridan Blvd.
Tel. (303) 934-5505
Zip 80226

CONNECTICUT

HARTFORD
Instrument Representatives, Inc.
P.O. Box 165
Glastonbury, Connecticut 06033
Tel. (203) 633-0777

FLORIDA

ORLANDO
BCS Associates, Inc.
940 N. Fern Creek Ave.
Tel. (305) 896-4881
Zip 32803

HAWAII

HONOLULU
Industrial Electronics, Inc.
646 Queen Street
P.O. Box 135
Tel. (808) 533-6095
Zip 96817

ILLINOIS

CHICAGO
Cozzens & Cudahy, Inc.
1301 N. Rand Rd.
Des Plaines, IL 60016
Tel. (312) 298-3600

INDIANA

INDIANAPOLIS
Cozzens & Cudahy, Inc.
Port O'Call Executive Ctr.
21 Beachway Drive
Tel. (317) 244-2456
Zip 46224

MARYLAND

BALTIMORE
Electronic Marketing Assoc. Inc.
11501 Huff Court
Kensington, Maryland 20795
Tel. (301) 881-5300, 744-7700

MASSACHUSETTS

BOSTON
Instrument Representatives, Inc.
109 Massachusetts Ave.
Lexington, MA 02173
Tel. (617) 861-8620

MICHIGAN

DETROIT
WKM Associates, Inc.
1474 East Outer Dr.
Tel. (313) 892-2500
Zip 48234

MINNESOTA

MINNEAPOLIS
Cozzens & Cudahy, Inc.
10800 Lyndale Ave. S.
Tel. (612) 884-4336
Zip 55420

MISSOURI

ST. LOUIS
Cozzens & Cudahy, Inc.
P.O. Box 10013
Lambert Field - Zip 63145
Tel. (314) 423-1234

NEW JERSEY

NEWARK
SBM Representatives
1519 Stuyvesant Avenue
Union, New Jersey 07083
Tel. (201) 687-8737

NEW MEXICO

ALBUQUERQUE
Barnhill Associates
1410 — D Wyoming N.E.
Tel. (505) 299-7658
Zip 87112

NEW YORK

NEW YORK
SBM Representatives
28 Hobby Street
Pleasantville, N.Y. 10570
Tel. (914) 769-1811

ROCHESTER
SBM Representatives
4515 Culver Rd.
Tel. (716) 226-1400
Zip 14622

NORTH CAROLINA

GREENSBORO
P.O. Box 9619
1310 Beahan Pl.
Tel. (919) 273-1918
Zip 27408

OHIO

CLEVELAND
WKM Associates, Inc.
16141 Puritas Ave.
Tel. (216) 267-0445
Zip 44135

DAYTON
WKM Associates, Inc.
6073 Far Hills Ave.
Tel. (513) 434-7500
Zip 45459

PENNSYLVANIA

PHILADELPHIA
Electronic Marketing Assoc.
210 Goddard Blvd., Ste. 100
King of Prussia, Pennsylvania
Tel. (215) 248-5050
Zip 19406

PITTSBURGH
WKM Associates, Inc.
90 Clairton Blvd.
Tel. (412) 892-2953
Zip 15236

TEXAS

DALLAS
Barnhill Associates
Suite 220
312 N. Central Express Wy.
Richardson, Texas 75080
Tel. (214) 231-2573

HOUSTON
Barnhill Associates
Suite 332
3810 Westheimer
Tel. (713) 621-0040
Zip 77027

WASHINGTON

SEATTLE
Showalter-Judd, Inc.
5616 4th Ave. South
Tel. (206) 762-2310
Zip 98108

CANADA

BRITISH COLUMBIA

VANCOUVER
Allan Crawford Associates, Ltd.
1820 Pandora St.
Tel. (604) 253-7136

ALBERTA

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Allan Crawford Associates, Ltd.
640 - 11th Ave. S.W.
Tel. (403) 261-0780

ONTARIO

MALTON
Allan Crawford Associates, Ltd.
6427 Northam Drive
Tel. (416) 678-1500

OTTAWA, 3
Allan Crawford Associates, Ltd.
376 Churchill Ave., Suite 106
Tel. (613) 829-9651

QUEBEC

LONGUEUIL
Allan Crawford Associates, Ltd.
157 (rue) St. Charles Street W.
Tel. (514) 670-1212

INTERNATIONAL REPRESENTATIVES

ARGENTINA
Coasin S.A.
Virrey del Pino 4071
Buenos Aires, Argentina

AUSTRALIA
Elmeasco Instruments
P.O. Box 334
Brookvale, N.S.W. Australia 2100

AUSTRIA
Kontron GMBH & Co., Kg.
Lederergasse 16
1080 Vienna, Austria

BELGIUM
C.N. Rood S.A.
37 Place de Jamblinne de Meux
1040 Brussels, Belgium

BRAZIL
Ambriex S.A.
Rue Ceara, 104 - 2.° e 3.° Andares
ZC - 29
Rio de Janeiro GB, Brazil

Ambriex S.A.
Rua Tupi, 535
01233 Sao Paulo SP, Brazil

CARIBBEAN
West Indies Sales Co.
606 Calle Aboy
San Juan, Puerto Rico 00907

CHILE
Coasin Chile Ltd.
Casilla 14588 - Correo 15
Santiago, Chile

CHINA, Peoples Republic Of
May Lee Industries, Inc.
475 Park Avenue South
New York, N.Y. 10016

COLOMBIA
Marones Ltda.
Apartado Aereo 90687
Bogota 8, Colombia

DENMARK
Tage Olsen A/S
1, Rønnegade
Copenhagen Ø, Denmark

ECUADOR
Proteco Coasin Cia., Ltda.
Apartado 228A
Quito, Ecuador

FINLAND
Oy Findip AB
P.O. Box 25
00521 Helsinki 52, Finland

FRANCE
M.B. Electroniques S.A.
29, Rue Emile Duclaux
92, Suresnes
France

GERMANY
Fey Elektronische Messgerate
8 Muenchen 19
Horemansstrasse 28
West Germany

GREECE
Marios Dalleggio Representations
2 Alopekis Street
Athens 19 Greece

HONG KONG & MACAU
Gilman & Co., Ltd.
P.O. Box 56
Hong Kong

INDIA
Hinditron Services Pvt. Ltd.
69/A Nepean Sea Road
Bombay-6 India

IRAN
Berkeh Company Ltd.
20 Salm Road, Roosevelt Ave.
Tehran, Iran

ISRAEL
R.D.T. Electronics Engineering Ltd.
19 Prof. Shor Street
Tel-Aviv, Israel

ITALY
Sistrel S.P.A.
Via Giorgio da Sebenico 11-13
Rome, Italy

JAPAN
Toyo Trading Co. Ltd.
P.O. Box 5014
Tokyo International
Tokyo 100-31, Japan

Suzuki Bldg.
2-38 Junkeicho-dori
Minami-ku, Osaka

KOREA
Asia Science & Co.
Internaltion P.O. Box 1250
Seoul, Korea

MALAYSIA
O'Connor's (Pte) Ltd.
P.O. Box 1197
Kota Kinabalu
East Malaysia

P.O. Box 91
Petaling Jaya, Selangor
West Malaysia

MEXICO
Mexitek, S.A.
Eugenia 408
Departments 1 y 5
Mexico 12, D.F.
Mexico

THE NETHERLANDS
C.N. Rood B.V.
13 - Cort van der Lindenstraat
Rijswijk (Z.H.) 2100
Netherlands

Fluke (Nederland) B.V.
Ledeboerstraat 27
Industrieterrein Noord
Tilburg, Netherlands

NEW ZEALAND
David J. Reid (N.Z.) Ltd.
C.P.O Box 2630
Auckland 1, New Zealand

NIGERIA
Deemtee Electrotechnics Ltd.
P.O. Box 3073
Lagos, Nigeria

NORWAY
Morgenstierne & Co. A/S
P.O. Box 6688 Rodeløkka
Oslo 5, Norway

PAKISTAN
Pak International Operations
505 Muhammadi House-McLeod Rd.
P.O. Box 5323
Karachi, Pakistan

PERU
Importaciones y Representaciones Electronicas S.A.
Avda. Franklin D. Roosevelt 105
Lima 1, Peru

PORTUGAL
Equipamentos De Laboratorio, Lda.
P.O. Box 1100
Lisbon, Portugal

SINGAPORE
O'Connor's (Pte) Ltd.
98 Pasir Panjang Road
Singapore 5, Singapore

SOUTH AFRICA
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P.O. Box 1257
Johannesburg
Republic of South Africa

P.O. Box 3641
Cape Town

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Enrique-Larretta 12
Madrid 16, Spain

SWEDEN
Teleinstrument AB
P.O. Box 490
S-16204 Vallingby
Sweden

SWITZERLAND
Kontron Electronic A.G.
Bernerstrasse Sud 169
8048 Zurich
Switzerland

TAIWAN-REPUBLIC OF CHINA
Heighten Trading Company, Ltd.
P.O. Box 1408
Taipei, Taiwan 104

THAILAND
G. Simon Radio Ltd.
30 Patpong Avenue
Suriwong
Bangkok, Thailand

THE UNITED KINGDOM
Fluke International Corp.
Garnett Close
Watford, WD2 4TT
England

URUGUAY
Coasin Uruguay S.A.
Cerrito 617 - 4° Piso
Montevideo, Uruguay

U.S.S.R.
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6263 Variel
Woodland Hills, Calif. 91364

VENEZUELA
Coasin C.A.
Apdo. Postal 50939
Sabana Grande No.1
Caracas 105
Venezuela

In Europe, contact FLUKE NEDERLAND, B.V., POST OFFICE BOX 5053, INDUSTRIETERREIN NOORD, TILBURG, THE NETHERLANDS

FLUKE REGIONAL SERVICE CENTER; THE NETHERLANDS

FLUKE (NEDERLAND) B.V.
P.O. BOX 5053
TILBURG, THE NETHERLANDS

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